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Increasing inequalities in longevity among Italian workers

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Abstract

This article examines the evolution of inequalities in life expectancy at 65 and all-cause mortality by socio-economic position (SEP) among Italian workers. Period life tables and negative binomial regression models are used to estimate longevity inequalities. The empirical assessment is carried out on two administrative datasets, one covering the entire population of private sector workers for the years 1990–2019 and the other covering the entire workforce in Turin for the years 1981–2019. We find that social inequalities in life expectancy and all-cause mortality have increased among Italian workers in recent decades. Several robustness checks confirm this worrying trend, especially for men. Longevity has improved for workers in the middle and high SEPs, while it has hardly changed for workers in the lowest SEP. We show that the estimated life expectancy differentials translate into a loss of pension wealth for the most disadvantaged categories, which also increases over time.

Keywords: mortality; life expectancy; inequality; socioeconomic position; income; occupational class; population health.
JEL classifications: D63, I14, J10

1. Introduction

Life expectancy has been rising steadily around the world, but there is still little evidence on the extent to which this improvement has been uniform across different segments of the labour force. Cross-sectional evidence shows that there are significant inequalities in longevity along the dimension of socio-economic position (SEP). People with lower SEP are more likely to suffer from physical and mental ill health and disability and to die at a younger age, leading to a gap in life expectancy between different socioeconomic groups (WHO 2008).

An ongoing debate is discussing the causality of these associations. Health inequalities may lead to differences in SEP (e.g. Adams et al. 2003; Chandra and Vogl 2010; Case and Paxson 2011), especially at later working ages, when the health status translates into SEP via the ability to work and prolong working life (Smith 1999, 2004). Conversely, several empirical studies using quasi-experimental designs have also found a causal effect of socioeconomic status on health or mortality (e.g. Lindahl 2005; Lleras-Muney 2005; Spasojevic 2010; Lundborg et al. 2016; Schwandt, 2018). For example, Lindahl (2005) finds that plausibly exogenous income shocks due to lottery winnings reduce mortality. Lleras-Muney (2005), on the other hand, shows that higher educational attainment lowers mortality, exploiting exogenous variations induced by compulsory education reforms in the USA. In fact, there are several ways in which SEP may directly and indirectly affect health and mortality trough specific causal mechanisms (Geyer et al. 2006), ranging from material deprivation (Schrijvers et al. 1999), exposure to low-quality jobs and harmful working conditions (Ardito et al. 2020; Belloni et al., 2022), financial strain and emotional distress (Lachowska 2017), social isolation and detrimental health behaviours (e.g. Schrijvers et al. 1999; Dabergott 2021).

Health inequalities caused or exacerbated by socio-economic disadvantage raise several policy concerns. Not only are they undesirable on ethical grounds, as they conflict with social justice and undermine social cohesion (Fleurbaey and Schokkaert 2011). They also have detrimental effects on individuals, communities, and society as a whole, as they result in significant economic and welfare losses, leading to increased welfare and health care expenditure and reduced earnings and tax capacity (Deaton, 2003; Grimm, 2011).[1] Moreover, longevity inequalities have implications for the redistribution and equity of pension systems (Auerbach et al. 2017; OECD 2018; Mazzaferro et al. 2012). Indeed, about two-thirds of OECD countries incorporate life expectancy (at birth or at retirement) into various automatic pension adjustment mechanisms.[2] As these mechanisms use average life expectancy to determine pension levels and eligibility, they introduce a regressive redistribution of pension resources in favour of higher socio-economic and occupational groups, which generally have higher than average life expectancies.

Are current improvements in life expectancies reducing these inequalities, or is the socio-economic gradient widening? Recent years have witnessed an upsurge in research on this question. Many studies have shown that socioeconomic inequalities in life expectancies among the elders are increasing over time. However, the available evidence comes mainly from North America (see e.g. Currie and Schwandt 2016; Bosworth 2018 for the USA; Baker et al. 2019 for Canada) and from Northern European countries (Brønnum-Hansen and Baadsgaard 2012; Tarkiainen et al. 2012; Zarulli, Jasilionis, and Jdanov 2012; Mortensen et al. 2016). Only recently evidence of increasing mortality divides has been published for previously unexplored countries, for example, Spain (González and Rodríguez-González 2021), Portugal (Costa and Santana 2021) and Czech Republic (Bertoli and Grembi 2021). These works, which are part of a special issue on the evolution of mortality inequality in 12 OECD countries (Banks et al. 2021), contributed substantially to the understanding on the evolution of mortality inequalities also in Southern and Eastern Europe, but relied on aggregated area-level SEP indicators and mortality rates adjusted only for age and gender. As for Italy, numerous studies have extensively documented the socioeconomic disparities in mortality and life expectancy (Belloni et al., 2013; Leombruni et al. 2015; d'Errico, Costa, and Zengarini 2017; Lallo and Raitano 2018; Petrelli et al. 2018; Alicandro et al. 2018; Petrelli et al. 2019). Despite this, there is a gap in research concerning the long-term trends of these differences up to recent years. To the best our knowledge, only our study and that of Ghislandi and Scotti (2022) have explored this aspect.

This study aims at contributing to the existing literature along the limits above mentioned. A strength of our study is that we use individual-level administrative data covering

[1] It has been calculated that if the European population had the health of the 50% most educated, there would be 700,000 fewer deaths per year and 33 million fewer cases of ill health across the European Union (Mackenbach, Meerding and Kunst 2011).

[2] These include linking benefits to life expectancy at retirement through longevity factors in notional defined contribution schemes and linking the statutory retirement age to life expectancy changes registered in the population (de Tavernier and Boulhol 2021).

the entire population of private sector workers in Italy. Therefore, beyond providing evidence on the long-term evolution of longevity inequality for a previously understudied country, we rely on SEP and mortality measures that are accurate and robust to reporting bias or loss to follow up. By using individual SEP, we also avoid the problems of selective migration and misclassification of individual exposure, which can arise with aggregated SEP measures (Chetty et al. 2016). Moreover, our income SEP based on quantiles is robust to changing definitions, size, and positive/adverse selection mechanisms (Dowd and Hamoudi, 2014). A limitation is that it is measured over a relatively short period of time (5 years). However, in our robustness analysis, we show that both individual occupation and income quartile groups are quite stable over the period of analysis (1990–2004) and that results are extremely robust to different definition of SEP and when we adopt different methods, specifications, and sample selections rules.

The results show that in Italy the gap in life expectancy at 65 between income and occupational groups has widened over time, especially for men. This trend is driven by a difference in the rate of growth of life expectancy, which has systematically increased for the advantaged categories, while it has barely improved for the disadvantaged groups. Back-of-the-envelope calculations show that the life expectancy gap translates into a significant loss of pension rights for those with a lower life expectancy, which also increases over time.

This article is structured as follows. Section 2 describes the measures and statistical methods used. Section 3 presents the results. Section 4 includes several robustness checks to test internal and external validity. A discussion of the results is given in Section 5, while Section 6 concludes.

2. Materials and methods

2.1 Data

Our primary data come from the administrative archives of the Italian National Institute of Social Security (INPS). INPS data represent the most complete and up-to-date statistical source of information to study mortality differentials between socioeconomic and occupational groups in Italy. They offer detailed information on job spells, welfare benefits and demographic characteristics of all insured workers at individual level. We analyse data of the population of private sector employees using the INPS archives for the years 1990–2019.[3]

Although the external validity of results based on INPS data is limited to private sector employees, it is worth noting that they represent more than 80% of all employees in Italy and 61% of the working population (INPS 2023). To increase the external validity of our conclusions, the analysis is replicated on the Turin Longitudinal Study (TLS), a longitudinal study based on population registers and censuses (Cardano, Costa, and Demaria 2004). Advantages of using the TLS are that it allows to test the validity of the INPS results on the whole population of workers, rather than limited to private sector employees only, and to examine changes during a longer time span (as the first census dates to 1981). For both INPS and TLS data, it is possible to conduct mortality follow-up by linking administrative records with administrative mortality registers up to 2019.

[3] The INPS archives contain separate archives which, in principle, make it possible to analyse the evolution of mortality differentials between different categories of workers, such as the self-employed, employees, and civil servants. Unfortunately, for the purposes of this article, none of these sub-groups can be fully considered without limitations, either separately or together with private employees. Data for civil servants are not available in the INPS archives for the years analysed. Nor is there a reliable measure of SEP for the self-employed, as the data only provide information on contributions paid, which cannot be used as a proxy for socio-economic position, since a special flat-rate tax allows them to pay the minimum flat-rate contribution regardless of their actual income. Similarly, there is no comparable SEP measure based on occupation or a standardized measure of weekly earnings for collaborators. In addition, the composition of collaborators has changed significantly during the period under consideration due to important legislative interventions such as the Biagi and Fornero reforms, which makes a comparison over time difficult.

Table 1. Sampling and mortality follow-up (FU) used to construct the analytical sample.

Period	Start FU		End FU	#Persons (millions)	#Person years (millions)
	Start sampling	End sampling			
'1990'	1 January 1990	31 December 1994	31 December 2009	12.50	245.06
'1995'	1 January 1995	31 December 1999	31 December 2014	12.98	255.11
'2000'	1 January 2000	31 December 2004	31 December 2019	14.22	279.65

Source: Authors' elaboration on Italian Social Security data, INPS, years 1990–2019.

For the analysis of private employees in the INPS data, the study period was divided into three 5-year windows: 1990–1994, 1995–1999, and 2000–2004. For each 5-year period, only employees with at least 1 month of employment, born in Italy and aged fifteen to ninety-five at the beginning of the period were selected. Individuals were followed up until the date of death (recorded at the year-month level) or until the end of follow-up (equivalent to 20 years). For example, the mortality follow-up for the 1990–1994 workers was from 1 January 1990 to 31 December 2009 (Table 1). From now on, the three samples will be referred to as '1990', '1995', and '2000' periods.

For each person in the three periods, all job spells observed during the relative 5-year window were piled. Individual career variables such as full-time equivalent average weekly wage, prevalent geographical area of work, main sector of activity, main occupational class, were constructed as averages or modes, weighted by the length of the work episode. An indicator of work intensity was defined as the proportion of weeks worked over the period of observation and categorized in low (<20%), mid (20–80%) and high (>80%).[4] To define weekly wage, we took the sum of reported employment inflation-adjusted earnings divided by the total number of full-time equivalent weeks worked and constructed an average weekly wage over the 5-year window for each period. The final analytical sample is described in Table 2.

As can be seen from Table 2, the composition of the three samples has changed over time, reflecting some of the macro-trends characterizing the Italian labour market during these years. We observe an increase in the average age of the samples over time, reflecting the ageing of the working population driven by overall ageing and recent pension reforms that have promoted the tightening of retirement eligibility conditions. We observe an increase of the share of workers employed in the services sector at the expense of the manufacturing sector, reflecting a general process of tertiarization of the economy. The most striking compositional change regards the increase in female participation, that in the 2000s increased by 25% with respect to the 1990s, against a more modest increase experienced by males. In Section 5, we discuss critically how the evolution of longevity gaps by SEP among females might be affected by the huge change in female employment rate.

2.2 SEP measures

The two SEP indicators used in this paper are based on income and occupational social class.

As an indicator of income, we used average full-time equivalent weekly wage. Individuals were ranked into deciles or quantiles calculated using cut-off points derived from the final dataset of analysis separately for men and women, and for each time-period.[5]

4 In Section 4, we checked that excluding those who worked less than 20% of the time or selecting only those who worked more than 80% of the time did not change the results.

5 The results are robust and confirmed when we adopt SEP measures based on income quantiles specific for each macro-area of work or macro-area of birth.

Table 2. Distribution of socioeconomic variables by period and gender, avg. or % of total persons.

	Men			Women		
Variable	1990	1995	2000	1990	1995	2000
Age	34.73	36.44	37.76	30.29	31.04	32.46
Geographic area of work						
North	0.56	0.56	0.54	0.62	0.62	0.60
Centre	0.19	0.20	0.20	0.21	0.21	0.20
South	0.25	0.24	0.26	0.18	0.18	0.20
FTE weekly wage (real)	525.46	554.35	556.00	400.25	419.90	425.45
Occupational class						
Blue-collar	0.71	0.70	0.69	0.54	0.53	0.52
White-collar	0.27	0.28	0.29	0.45	0.46	0.48
Executives	0.02	0.02	0.02	0.004	0.006	0.004
Economic sector						
Primary and construction	0.17	0.18	0.18	0.02	0.03	0.03
Manufacturing	0.44	0.41	0.37	0.38	0.33	0.28
Services	0.39	0.42	0.45	0.60	0.64	0.69
Work intensity						
Low (<20%)	0.16	0.17	0.15	0.22	0.23	0.22
High (>80%)	0.51	0.49	0.53	0.38	0.35	0.35
No. of Persons	7,974,849	8,100,832	8,589,521	4,520,664	4,874,688	5,634,472
% Change vs 1990		+2	+8		+8	+25

Notes: Authors' elaboration on Italian Social Security data, INPS, 1990–2019. FTE, full time equivalent.

Using income quantiles as SEP measures offers several advantages as they group individuals into equal shares of the population, helping to address the problem of measurement error in mortality rates for small groups when analysing age classes with low deaths counts, and limiting problems related to changing selection and composition or measures definition over time.

Occupational social class has been classified into three categories (executives, white-collar, and blue-collar), as the original variable in the INPS data does not allow further disaggregation. While income is related to variations in material conditions and social status, occupational position ought to depict (varying control over) working conditions and potential exposure to occupational hazards and strain (Geyer et al. 2006). This indicator has been used in previous studies on life expectancy inequality based on INPS and TLS data (Leombruni et al. 2015; d'Errico et al. 2017), thus allowing for easier comparison and replication of previous results. A limitation of occupational position as a measure of SEP is that it suffers from a changing composition over time. Indeed, similar to SEP based on educational attainment, there is a risk of increasing adverse selection at lower levels and decreasing positive selection at higher levels, requiring a more cautious interpretation of changes over time (Dowd and Hamoudi 2014). Therefore, using both income-based and occupation-based SEP will help us to gain a more comprehensive understanding of the relationship between SEP and the evolution of longevity differentials.

2.3 Methods

We use period life tables to calculate life expectancy. Period life tables are a standard tool used in demography and actuarial science to analyse mortality and calculate life expectancy at different ages (Smith and Bradshaw 2006; Ayuso, Bravo, and Holzmann 2021). Moreover, the method is used by Italian government and other statistical institutions to calculate changes in life expectancy to link pension rules to longevity (Italian Law 122/2010, art. 12). Thus, we consider this technique reliable to calculate changes in life expectancy over time, and also relevant from a policy perspective.

In general terms, a life table shows, for each age and year, the probability that a person will die before his or her next birthday. There are two types of life table: cohort and period. While cohort life tables show the overall mortality rates of a given cohort (year of birth) over the course of their lives, period life tables show the mortality rates during a given period for a given population. Although cohort life tables are in principle more accurate measures of life expectancy, they are less widely used due to their data-intensive nature, requiring historical data on fully exhausted cohorts (Guillot 2011). When examining cohorts that are not yet exhausted, the method relies on strong assumptions to make out-of-sample predictions about cohort- and sex-specific expected future changes in mortality. For these reasons, national governments typically use period life tables to calculate life expectancy and mortality rates to link pension rules to longevity (Ayuso, Bravo, and Holzmann 2021).

In our analysis, we calculated period specific mortality rates for age, sex, income quantile, and occupational class, as the ratio between the number of individuals who died in the age interval by the total population-years at risk in that age interval. To reduce fluctuation, we constructed abridged period life tables using 5-year age intervals with a final age interval of 85+ to estimate life expectancy and confidence intervals (CIs) using the method described by Chiang (1968), with adjustments to the standard errors as proposed by Silcocks, Jenner, and Reza (2001), as described by Eayres and Williams (2004). Using 5-year age intervals (rather than individuals' years of life) is standard in adult mortality analysis, as it helps to minimize noise due to measurement error and to avoid zero deaths and person-years <5000 in some of the cells (Toson and Baker 2003). The baseline for age covers the age range from fifteen to ninety-five, whereas the mortality follow-up is 20 years; consequently, we follow all workers for the same length but no individual in the sample is really observed ageing from age fifteen to ages ninety-five.

We examined life expectancy at the age of 65 years. Our measure of life expectancy inequality is the difference in life expectancy at sisty-five between the top and bottom SEP categories. We estimate its standard error and 95% CIs assuming that the difference between two life expectancies is normally distributed, as shown by Eayres and Williams (2004).

Since estimation of the trend in life expectancy differentials might be biased by omitted variables or by labour market compositional changes across years, we complement the analysis by running a multivariate negative binomial regression model on the samples described in Table 2. Negative binomial (NB) estimates the expected number of events (deaths, Y) as function of known covariates X and the time at risk measured in person years (py). The estimated regression coefficient indicates by how much the log of the expected count of deaths (technically, the death rate) varies due to a unitary change of X, holding constant the remaining vector of sociodemographic characteristics shared by individuals within each stratum[6]. To do so, we build strata defined by age (fifteen categories), time period (three categories), region of birth (twenty categories), macro-region of work (five categories), economic activity (11 ISIC rev. four categories), work intensity (three categories: low, mid, high), firm size (three categories: low, mid, high), occupational class (three categories), income quantiles (four or ten categories), and count the number of deaths and person-years at risk within each stratum (mortality follow-up is 20-years as in the life expectancy analysis).

We first assess the presence of social inequality in mortality by income quartiles ($IncomeQ_k$) on the pooled sample (combining the 1990, 1995, and 2000 periods) by estimating the Equation (1) separately by sex:

$$\log(Y) = b_0 + \sum\nolimits_{k=1}^{4} IncomeQ_k + X + \log\ (py) \tag{1}$$

[6] We preferred NB to Poisson model because our dependent variable had variance larger than the mean, that is, it was over dispersed, and NB is more efficient and less prone to downward bias in case of overdispersion (Cameron and Trivedi 1986).

Our measure of longevity inequality is obtained exponentiating the coefficient of the bottom quartile group $IncomeQ_1$, which represents the mortality rate ratio (MRR) of the bottom compared to the top quartile group. Estimates are adjusted for the included controls X and the time of exposure. The vector of X includes occupational class (three categories), age (fifteen categories), period (three categories), region of birth (twenty categories), macro-region of work (five categories), economic activity (eleven ISIC categories), work intensity (three categories), firm size (three categories).

To test the presence of a temporal trend in social inequality in mortality, we introduce interaction terms between our main SEP measure ($IncomeQ_k$) and period, to compare the MRR for low-income versus high-income across the 1990, the 1995, and the 2000 periods:

$$\log(Y) = b_0 + \sum\nolimits_{k=1}^{3} IncomeQ_k * \sum\nolimits_{i=1990}^{2000} period_i + X + \log\ (py) \tag{2}$$

Finally, to demonstrate the robustness of results, and their internal and external validity, several sensitivity analyses were conducted (see Section 4).

3. Results

3.1 Life expectancy inequality

Figure 1 plots life expectancy at sixty-five (and 95% CIs) in Italy by income decile, calculated separately for males and females, for the most recent group among the three taken into consideration. Several elements confirm the results on social mortality differentials highlighted by previous literature. A direct socio-economic gradient in life expectancy is present in both sexes, steeper for men than for women. Among men, the gap between the highest and lowest income decile is 2.2 years (95% CI 2.14, 2.32). Among women, the same gap is of 0.36 years (95% CI 0.23, 0.50), roughly corresponding to 4 months. A similar pattern emerges when using as a SEP indicator occupational social class or income quartile (Supplementary Table A1, panel A).

In the following analyses, we narrow the comparison to the change in life expectancy at age sixty-five between people in the highest income quantiles (quartiles and deciles) and occupational classes versus those in the lowest corresponding category in the years 1990, 1995, and 2000. The results displayed in Fig. 2 show that social inequality in life expectancy has progressively increased over time. Specifically, concerning income, we found that among men the life expectancy disadvantage experienced by those in the bottom 25% of the income distribution has increased over the last decades, rising from 1.09 years in 1990 (95% CI 1.03, 1.15) to 1.79 years in 2000 (95% CI 1.73, 1.85). For women, the study

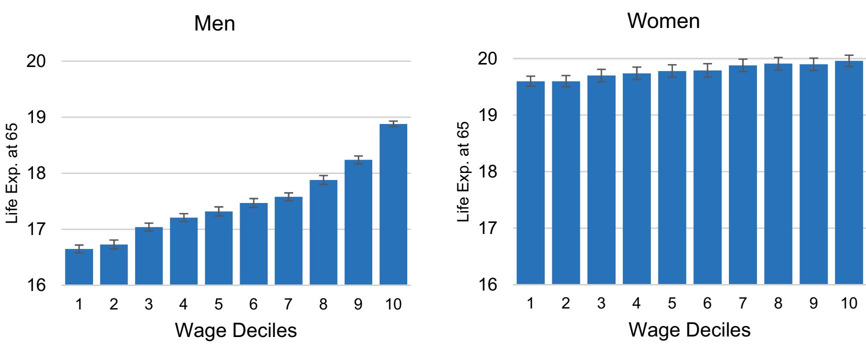

Figure 1. Life expectancy at 65 years and 95% CIs by income deciles and sex, 2000 sample.
Source: Authors' elaboration on Italian Social Security data, INPS, 1990–2019. Mortality follow-up is 20 years.

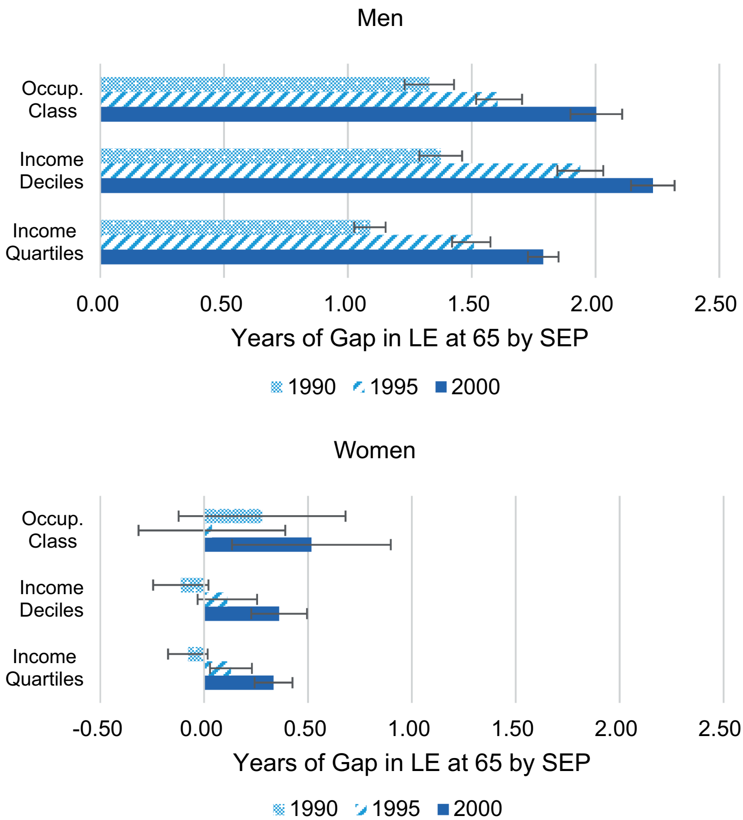

Figure 2. Trend of difference in life expectancy at 65 years for highest compared to lowest SEP, by sex and different SEP measures.

Source: Authors' elaboration on Italian Social Security data, INPS, 1990–2019. Mortality follow-up is 20 years. LE, life expectancy; SEP, socioeconomic position. Income deciles (q10), income deciles. Income (q4), income quartiles.

found no significant difference in the life expectancy at age sixty-five between the richest and the poorest quartile in 1990 (95% CI −0.17, 0.02). However, there was a small but significant advantage of about 2 and 4 months of life expectancy for the richest quartile in the 1995 and in 2000 groups, respectively.

The study comes to similar conclusions when income decile or occupational class is used as an indicator of SEP. As Fig. 2 shows, regardless of the measure of SEP used, the results confirm large and increasing inequalities in life expectancy for men. For women, the gap is smaller than for men and only appears in the most recent years.

In Supplementary Table A1, the study provides a detailed evaluation of the absolute and relative changes in life expectancy for all SEPs. This analysis reveals varying rates of improvement in life expectancy among different subgroups over time. For both men and women, and for all the SEP measures examined, a gain in life expectancy from the 1990 to the 2000 group is seen only among the highest and the mid-SEP groups, while the lowest-SEP group shows almost no positive trend in life expectancy.

3.2 Regression analysis

Table 3 presents MRRs and 95% CIs from negative binomial regression models for all-cause mortality in the pooled sample (combining the 1990, 1995, and 2000 periods), stratified by gender (Equation 1). The results indicate that there are significant higher MRR

Table 3. Mortality rate ratios from negative binomial regression model, by sex.

Covariates	Men		Women	
	Equation 1 MRR [95% CI]	Equation 2 MRR [95% CI]	Equation 1 MRR [95% CI]	Equation 2 MRR [95% CI]
Income quartile				
Q_1 (first 25%)	1.573*** [1.562,1.584]		1.102*** [1.088,1.115]	
Q_2 (second 25%)	1.330*** [1.321,1.339]		0.998 [0.986,1.010]	
Q_3 (third 25%)	1.173*** [1.166,1.179]		0.976*** [0.966,0.987]	
Q_4 (fourth 25%)	1 [1.000,1.000]		1 [1.000,1.000]	
Interaction Year X Q_k				
year1990 X Q_1		**1.399***** [1.385,1.414]		**0.997** [0.977,1.017]
year1990 X Q_2		1.230*** [1.217,1.242]		0.953*** [0.933,0.972]
year1990 X Q_3		1.093*** [1.083,1.103]		0.960*** [0.941,0.978]
year1995 X Q_1		**1.590***** [1.574,1.607]		**1.093***** [1.072,1.114]
year1995 X Q_2		1.336*** [1.323,1.350]		0.989 [0.970,1.008]
year1995 X Q_3		1.194*** [1.182,1.205]		0.980** [0.962,0.998]
year2000 X Q_1		**1.737***** [1.720,1.755]		**1.197***** [1.176,1.218]
year2000 X Q_2		1.432*** [1.418,1.446]		1.045*** [1.027,1.064]
year2000 X Q_3		1.237*** [1.225,1.248]		0.991 [0.974,1.007]
Year				
1990	1 [1.000,1.000]	1 [1.000,1.000]	1 [1.000,1.000]	1 [1.000,1.000]
1995	0.892*** [0.888,0.896]	0.831*** [0.823,0.838]	0.954*** [0.945,0.963]	0.920*** [0.905,0.936]
2000	0.859*** [0.855,0.863]	0.763*** [0.756,0.770]	0.928*** [0.920,0.937]	0.863*** [0.849,0.877]
Occupational Class				
Blue-collar	1.471*** [1.451,1.490]	1.477*** [1.458,1.495]	1.110*** [1.062,1.160]	1.110*** [1.062,1.160]
White-collar	1.200*** [1.192,1.210]	1.208*** [1.198,1.215]	1.058*** [1.021,1.095]	1.061*** [1.024,1.099]
Executives	1 [1.000,1.000]	1 [1.000,1.000]	1 [1.000,1.000]	1 [1.000,1.000]
Obs.	3,051,727	3,051,727	1,084,263	1,084,263

Notes: The table displays MRR adjusted for the displayed covariates plus: age (15 cat.), region of birth (20 cat.), macro- region of work (5 cat.), economic activity (11 ISIC cat.), work intensity (3 cat.: low, mid, high), firm size (3 cat.: low, mid, high). *Source:* Authors' elaboration on Italian Social Security data, INPS, 1990–2019. Mortality follow-up is 20 years. Bold sign used for the interaction between lowest income quartile category and period.

* $P < .05$. ** $P < .01$. *** $P < .001$.

between the lowest-income quartile groups (Q1) and lowest occupational class (blue-collar) compared to those with higher SEP, even after adjusting for period, age, region of birth, and several work characteristics, and mutually adjusting for the two dimensions of SEP. For men, the study found that those in the lowest-income quartile and blue-collar worker groups had mortality rates that were 1.57 and 1.47 times higher, respectively, compared to those in the highest-income group and executive positions. For women, the analysis revealed an excess risk of mortality of about 1.10 associated to both the poorest income group and the lowest occupational class. Hence, in both genders income and occupational class appear to be significant independent predictors of mortality, although the MRR of one SEP dimension decreases when the other is included (the inclusion of occupational class lowers the MRR associated to Q1 by about 12% for men and 3% for women).

We have examined the presence of heterogeneity in longevity inequality by running equation 1 on different subpopulations. The results show that longevity inequalities are widespread and present in all the strata analysed. Larger differences are found in the north of Italy, in the primary and secondary sectors and among workers employed in larger enterprises. The pattern is similar for men and women (see Supplementary Fig. A1).

In Equation (2), we examined the presence of a trend in social inequality in mortality by replacing the income SEP variables with the interaction terms Year $\times$ SEP. By examining these interactions, the study was able to understand the extent to which the association between SEP and mortality differed significantly across the three periods. The results from Equation (2) revealed a clear social and temporal gradient. Specifically for men, the study found that individuals in the lowest-income quartile in 1990 had a 40% higher mortality rate than those in the highest-quartile. This increased to 60% and 74% higher death rates in the 1995 and 2000 periods, respectively, with no overlap in the CIs, suggesting that the gradient has increased over time. For women, there is also some evidence that mortality inequality has increased over time. While there was no disadvantage for low-income individuals in the 1990 sample, we find a 9% and 20% higher mortality rate for low-income women compared to high-income women in 1995 and 2000, respectively. Despite several robustness checks, the social and temporal gradients remain fully robust (see Section 4).

To explore our main findings further, we used the results from the fully adjusted and interacted model to predict the standardized number of deaths for each income quartile, separately for men and women, and we plot these in Fig. 3.

Figure 3 shows the extent to which predicted death rates have fallen over time for each income group. The decline in mortality rates between 1990 and 2000 was steeper as income increased and was greatest for the top income quartile. These findings were particularly striking for women, as the study found that no reduction in death rates occurred for the poorest 25%, while a small but significant reduction in death rates occurred only for the top income group. These results confirm that longevity has not improved equally for all groups, and for some groups it has hardly improved at all, even when accounting for changes in individual and contextual characteristics.

4. Robustness

4.1 Internal validity

We have carried out several checks to verify the internal and external validity of our results.

In terms of internal validity, a possible concern relates to the endogeneity between mortality and SEP and the possibility that a short-term illness could cause both a reduction in income and a higher risk of death, which would exaggerate the SEP-mortality gradient. Use of a long-term measure of SEP greatly reduces this problem, particularly if it describes incomes earlier in life relative to the survival outcome (Auerbach et al. 2017). To address this issue, two robustness tests were conducted. First, following the reasoning of Auerbach et al. (2017), we have

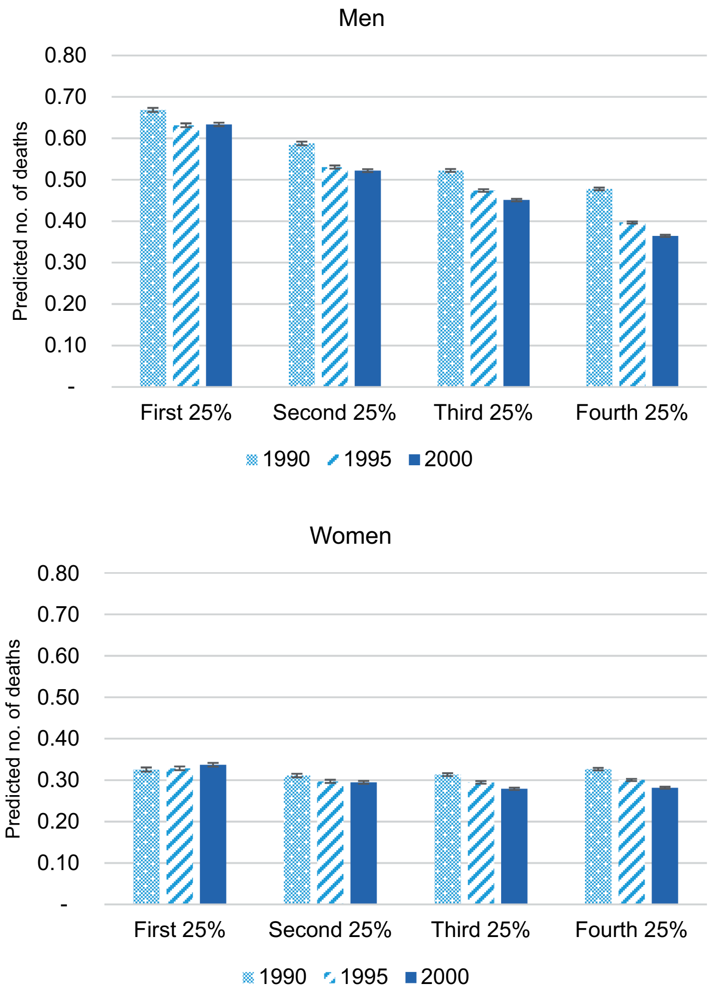

Figure 3. Trend of Standardized Predicted Number of Deaths from Negative Binomial Regression Model (Equation 2), by sex and SEP measure based on income quartile.

Notes: Predicted number of events from Negative Binomial Regression (Equation 2). 95% confidence intervals based on standard errors estimated using delta method. *Source:* Authors' elaboration on Italian Social Security data, INPS, 1990-2019. Mortality follow-up is 20 years.

increased the time spam between SEP and mortality measures by 10 years, excluding the first half of the 20-year mortality follow-up and considering only deaths that occurred in the second half, to reduce the risk that what we are capturing is driven by premature mortality of individuals with concurrent limited health and earning capacity. Second, for the manual workers subsample only, we were able to explicitly control for a proxy for prior health at baseline (weeks of sick leave) by adding it to the controls and then stratifying the sample into good/bad health strata.[7] The results show that even when we restrict the sample to manual workers with good health at baseline, the MRR and the gap in life expectancy between the top and bottom income

[7] INPS archives provide reliable information on sickness absenteeism only for blue-collar. Sick leave is a valid proxy of ill health in working populations (Vahtera, Pentti, and Kivimäki 2004).

quartiles increase over time for both men and women (robustness tests R1 and R2: Supplementary Table B1 and Supplementary Figs B1 and B2).

An additional challenge to internal validity relates to the use of a methodology and a sample selection rule that compares consecutive years, which may result in some individuals contributing to the estimation of more than one period. However, a sensitivity analysis was carried out using mutually exclusive samples, that is, person-years observations were randomly selected so that individuals belonged to only a single group period. This exercise shows that even with this adjustment, all results were confirmed, and the magnitudes were almost identical to the main analyses (R3: Supplementary Table B1 and Supplementary Figs B1 and B2).

Furthermore, we address potential concerns about the accuracy of the SEP measure. The SEP variables are defined as the prevalent occupation and average earning capacity. These variables were assessed during either the 5-year baseline window immediately prior to the start of the mortality follow-up (as per the main specification) or 10 years prior to the mortality follow-up (as per the robustness check R1). To address the possibility that the main results might be driven by individuals for whom this measure of SEP may not accurately reflect their true SEP over time, a series of robustness checks were conducted. Specifically, we focused on individuals with high employment attachment more likely to be observed in their meaningful and primary job, that is, workers who during the baseline 5-year window were employed for at least 80% of the observed time (R4), did not combine work and an old-age or disability pension (R5), and whose age was below 65 (R6). The results, presented in the Supplementary Table B1 and Supplementary Figs B1 and B2, confirm the main findings of this study, showing that even among these highly selected workers there was a socio-economic gradient in longevity, which was stronger for men and became more pronounced over time.

Moreover, by selecting individuals who were present in all three periods, we could construct a long-term measure of SEP based on longitudinal data covering 15 years of work history, which is more likely to serve as an accurate proxy for vital SEP. This analysis showed, first, that SEP remained stable over the three periods,[8] and, secondly, revealed an estimated gap in life expectancy between the lowest and highest SEPs of similar magnitude to that obtained in the primary analysis for both men and women (Supplementary Table B2).

4.2 External validity

As regards the assessment of external validity, our tests aim to show the extent to which the results can be generalized beyond the specific sample of participants (private sector workers) and years (1990–2004) analysed.

First, the study on the evolution of life expectancy at age 65 was replicated on the TLS, another administrative data source covering the entire workforce of the city of Turin (the fourth largest city in Italy). The TLS is a prospective mortality study covering all residents of Turin participating the 1981, 1991, and 2001 censuses. The TLS allows the results to be tested on all strata of the workforce, not just those working in the private sector, and on a longer time horizon, going back a decade to the periods covered by the main analysis. The TLS results confirm the main findings of the paper for men, showing widening inequalities in life expectancy at sixty-five between the lowest and highest occupational classes. However, for women, the results did not show significant differences in life expectancy in any of the years. This inconsistency calls into question the hypothesis that longevity

8 Descriptive evidence on this selection of workers reveals that prevalent occupation-SEP is very stable. More than 95% of individuals do not change it over the 15-years period. The share of workers who remain in the same income-quartile-SEP over the 15-years period is about 70% for Q1; 60% for Q2; 66% for Q3; 91% for Q4

inequality is also emerging for female workers, at least when the reference population includes the public sector (Supplementary Fig. B4).

As a further test for external validity, we have extended the analysis on INPS data to more recent years also including persons at work in the years 2005–2009, increasing the longitudinal perspective of the analysis to four time points (rather than three), at the expense of shortening the mortality follow-up to 15 years. The results displayed in Supplementary Fig. B5 confirm that the gradient in life expectancy continues to worsen, even when considering more recent years.

Finally, we analysed the life expectancy inequality of the population of retired private sector workers by utilizing data from the INPS social security records of pensions available from 1995. We sampled three groups of pensioners based on their retirement years: 1995–1997, 1998–2000, and 2001–2003. The selection criteria included receiving an old age/early retirement pension from the INPS Fund for Private Sector Employees and having already retired by the age of sixty-five. The mortality follow-up period for the study was 18 years, and we defined SEP using sex- and year-adjusted monthly pension benefit quartiles. The results, shown in Supplementary Fig. B5, support the main findings of the study. Socio-economic inequalities in life expectancy at age sixty-five were observed between the top and bottom SEP groups, and this gap has widened over time. The gradient is more marked for men, while for women it only appears in the most recent cohort, in line with our previous findings for private sector employees. Moreover, the gradient is more pronounced among retirees with more years of contributions, suggesting that pension wealth may be a more reliable proxy for true SEP when analysing a more homogeneous sample of retirees with longer career histories.

To gain further insight, we conducted back-of-the-envelope calculations to estimate the potential loss in pension wealth associated with the differences in life expectancy that we estimated for retirees at age sixty-five, considering those with at least 10 years of contributions. Our analysis reveals that if men in the bottom 25% of the pension distribution had the same life expectancy as the top 25% group, their pension wealth would have been approximately 20,000 euros higher for those who retired in 1995–1997 and 24,000 euros higher for those who retired in 2001–2003, due to the increased life expectancy differential. On the other hand, the loss is relatively smaller for women in the lowest pension quartile group, amounting to approximately 1000 euros, reflecting the smaller life expectancy gap in this group (refer to Supplementary Table B3).

5. Discussion

Our study explores the evolution of life expectancy and mortality differentials using period life tables and negative binomial regression models. In the main analyses, we use administrative social security data from 1990 to 2019 covering the population of private sector employees in Italy. The results show a worrying trend of increasing longevity inequalities between income groups and occupational categories, driven by a differential trend in survival improvement. The finding are confirmed on different years and subpopulations, and when we control for baseline health and other personal and work characteristics. The longevity gradient is larger for men. For women, the gradient seems to have emerged only in recent years.

Like us, several other scholars reported among men increasing inequality in life expectancy and mortality using a varied range of SEP measures[9] and approaches. While Auerbach et al. (2017) analysis of mortality differentials was cohort based, like those of

[9] For examples, studies used individual income (Blakely et al. 2005; Tarkiainen et al. 2012; Kalwij, Alessie, and Knoef 2013; Chetty et al. 2016; Haan, Kemptner, and Lüthen 2020), area-level income (Currie and Schwandt 2016; Bär et al. 2021), occupational class (Martikainen, Blomgren, and Valkonen 2007; Bengtsson, Dribe, and Helgertz 2020), and education (Meara, Richards, and Cutler 2008; Cutler et al. 2011; Brønnum-Hansen and Baadsgaard 2012).

Bosworth et al. (2016) and (Waldron, 2007), there have been a number of rigorous cross-sectional studies that have found widening of the differentials up to the present time. For instance, studies conducted by Chetty et al (2016) and Currie and Schwandt (2016) have demonstrated this widening trend among older men. Importantly, we are not aware of any studies indicating a recent narrowing of these differentials or a slowdown in their widening among men.

Estimates for women present a more nuanced picture. While it is well known that females often have smaller longevity differentials than males (Mustard and Etches 2003; Currie and Schwandt 2016; Bengtsson, Dribe, and Helgertz 2020), the evidence on trends is less clear. Consistent with our findings, other studies point to an increasing mortality gradient (Singh and Siahpush 2006; Bengtsson, Dribe, and Helgertz 2020; González and Rodríguez-González 2021). However, some suggest a slightly decreasing gap (Blakely et al., 2005), and it's not uncommon for researchers to focus exclusively on men, as estimates of mortality differentials for female workers are unstable due to their fluctuating labour force participation rates over time (Waldron 2007; Bosworth and Burke 2014; Auerbach et al. 2017).

In our study, we found that women did not exhibit significant life expectancy or mortality gradients in the 1990s. These gradients only became apparent in the 2000s when we focused exclusively on private sector employees. As female employment experienced a sharp increase during the same period, it is plausible that this contributed to the rise in longevity differentials in several ways. First, as female participation increases in a country with traditionally low employment rates concentrated among high-wage women, positive selection may diminish (Olivetti and Petrongolo, 2008). Additionally, as more women enter jobs with more demanding or unfavourable working conditions, it could lead to increased morbidity and mortality among women from lower socio-economic backgrounds, thereby widening the differentials. Thirdly, using individual earnings or occupational class as indicators of women's socioeconomic status may be inadequate when work histories are fragmented, and a significant proportion of women are not in the labour force or work part-time (Scherer and Reyneri 2008). In such cases, using a SEP based on the highest income or occupational class within the couple/household may have more discriminatory power than individual income or occupation (Bosworth and Burke 2014).

Like previous studies, our analyses also revealed a differential trend among SEP groups, as for individuals in the bottom income quartile or in the lowest occupational class survival hardly changed over time, while marked improvements were evident among top-SEP individuals. The negative binomial models also support this finding, even when we adjust for several individual and work characteristics. These results are in line with Chetty et al (2016), who using tax records linked to the mortality registry showed that between 2001 and 2014, life expectancy at forty in the USA increased by 2.3 years for men and 2.9 years for women in the top 5% of the income distribution, but there was essentially no change for those in the bottom 5%. Similarly, evidence of stagnation of life expectancy among the lowest-SEP was found in Finland (Tarkiainen et al. 2012) and in Germany (Haan, Kemptner, and Lüthen 2020).

Unfortunately, due to limitations in our data, we were unable to investigate potential driving mechanisms or changes in other health dimensions that may have contributed to the increasing inequality in longevity. Studies point to increasing alcohol-related mortality in the working-age (Tarkiainen et al. 2012), cardiovascular diseases (Tarkiainen et al. 2012; Zarulli, Jasilionis, and Jdanov 2012; Bär et al. 2021 for men only), cancers (Zarulli, Jasilionis, and Jdanov 2012) and lung diseases (Currie and Schwandt 2016; Fenelon and Preston 2012), suggesting that unequal changes in individual risk factors, such as smoking, obesity, drug and alcohol abuse, are contributing factors.

Nonetheless, we can expect that also other changes might have contributed too, such as widening wage and wealth inequality (Devicienti, Fanfani and Maida 2019; Acciari and Morelli 2020), worsening of working conditions (Adăscăliței, Heyes, and Mendonça 2022; d'Errico et al. 2022) and a tendency toward late exit from the labour market (Eibich 2015; Ardito et al. 2020; Carrino, Glaser, and Avendano 2020).

In addition, there is widespread agreement that inequalities in access to health care play a significant role in the widening longevity gap. People from low socio-economic backgrounds often face barriers to accessing the most effective health care options and making the best use of health care resources. As a result, they tend to benefit less from improvements in health and advances in medical technology than those with higher socio-economic status. In this way, medical advances may inadvertently exacerbate the unequal use of healthcare, ultimately leading to increasing disparities in life expectancy (Frankovic and Kuhn, 2019).

6. Conclusion

Despite the abundance of evidence showing improvements in longevity over the past decades, we still have limited knowledge about the distribution of these gains across different time periods and socio-economic groups.

This study focuses on Italy and reveals that individuals with disadvantaged social status at work, measured by lower income or occupational grade, are at a higher risk of mortality. The study also finds that inequality in mortality has widened over time, driven by different rates of growth in life expectancy.

It is noteworthy that this finding appears to be a global phenomenon, as evidence suggests a similar pattern in other high-income countries with different versions of universal healthcare, including several European nations, Canada, and the USA.

Hence, this situation raises several policy relevant concerns. First, rising health inequality poses an ethical problem and hampers social justice. Secondly, it may undermine social cohesion, human development, and economic progress. Additionally, it casts the attention on the role of health in contributing to the overall rise in inequality across various economic dimensions that has been observed. Finally, differences in longevity have important implications for the equity of pension systems, as they alter the distribution of lifetime benefits in favour of higher income and more advantaged groups.

It is therefore of utmost importance to identify the causes leading to the pervasive widening inequality in health and longevity. Moreover, gaining a comprehensive understanding of how policies and institutions can contribute to resolving this issue becomes critical.

Author contributions

CA designed the study in collaboration with RL, AdE and GC. CA conducted the study and data analysis of INPS data. NZ was responsible for the TLS data analysis. CA drafted the first draft of the manuscript. All authors contributed to the interpretation of the results and to the final version of the manuscript. All authors read and approved the final version of the manuscript.

Supplementary material

Supplementary material is available on the OEP website, including an online appendix and computer programs to replicate the main results of the paper. The INPS and TLS data used in this paper are confidential, their use is restricted and cannot be published online. Requests for access to INPS data should be sent to dcstudiericerche@inps.it and requests for access to TLS data should be sent to sepi@epi.piemonte.it. The authors remain available to provide further information and assistance to interested researchers.

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Conflict of interests

None.

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