Network for Studies on Pensions, Aging and Retirement

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NETSPAR ACADEMIC SERIES

DP 01/2022-004

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Chiara Ardito[1]*, Nicolás Zengarini[2], Roberto Leombruni[3], Angelo d'Errico[2], Giuseppe Costa[4]

Abstract

This article investigates the evolution of inequalities in life expectancy at 65 and all-cause mortality by socioeconomic position (SEP) in Italy.

For this study, we used two large administrative data sets, one covering the Italian private sector employees' population in the years 1990–2019, the other covering for the years 1981–2019 all private and public sector workers of Turin, the fourth largest city of Italy.

Life table techniques are used to estimate the evolution of life expectancy at 65 years by different income quantiles and occupational classes. Negative binomial regression analyses are performed to calculate the interaction effect of socio-economic position and year on mortality controlling for several individual and contextual factors and the mutual adjustment of the second measure of SEP.

We find that social inequalities in life expectancy at 65 and all-cause mortality have widened in Italy during the last decades because longevity improved for mid- to high SEP individuals whereas it hardly changed for workers in the lowest SEP.

These results have important implications also for pension policies as inequalities in longevity may imply regressive redistribution and undermine the equity of a pension system.

Keywords:

Mortality, Inequality, Socioeconomic Position, Income, Occupational Class, Population Health.

JEL classification:

D63, I14, J10.

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1. Background

Life expectancy around the world is increasing steadily, but the evidence on how uniform this improvement is for different segments of the population is still scant. Cross sectional evidence shows that there are relevant longevity inequalities along the socioeconomic position (SEP) dimension. Individuals with lower SEP are more likely to suffer from physical and mental illness, disability and to die at younger ages, resulting in a gap in average life expectancy between different socio-economic groups (WHO 2008). 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 et al., 2011).

An ongoing debate is discussing the causality of these associations. Indeed, health inequalities can lead to differences in SEP (e.g., Adams et al. 2003; Case and Paxson 2011; Chandra and Vogl 2010), especially in later working ages when the health status translates into SEP via the ability to work and extend working life (Smith 1999, 2004). A large literature, however, including several empirical studies using quasi-experimental designs, has also identified a causal effect of socioeconomic status on health or mortality (e.g., Lindahl 2005; Lleras-Muney 2005; Lundborg et al. 2016; Spasojevic 2010). There are in fact several ways in which SEP may directly and indirectly influence health and mortality via specific causal mechanisms (Geyer et al. 2006), ranging from material deprivation (Schrijvers et al. 1999), financial strain, emotional distress (Lachowska 2017), social isolation and harmful health behaviors (e.g. Schrijvers et al. 1999; Dabergott 2021), all of which seems responsible for a large part of socioeconomic health differences. Income guarantees access to healthy food, good accommodation, better and quicker medical treatment, and other goods that are directly or indirectly related to preserving health. Education is important in providing knowledge and cognitive skills for dealing with complex information such as health risks, healthy behavior, the relationship between own behavior and personal health, and for looking timely for health care in case of illness. Social capital is helpful when a person needs information, networks, and emotional and practical support (Hoffmann 2011).

Inequalities in health emerging or being amplified due to socio-economic disadvantages are not only ethically unacceptable, but also a huge economic and welfare loss for both the individuals and the State, which will spend more on social welfare and health care, receiving lower revenues due to the reduced taxpaying capacity. Longevity inequalities have important consequences also in terms of redistribution and equity of pension systems (Mazzaferro et al.

2012; Caselli & Lipsi, 2018; OECD, 2018; Ardito & d'Errico 2018; Ardito et al. 2019). In fact, life expectancy is a key parameter used in the definition of many rules and principles governing pension systems. Italy, like many other European pension systems, has introduced and strengthened mechanisms that automatically link pension benefits to average life expectancy at 65, through the transformation coefficients which convert cumulated contributions into a stream of monthly benefits according to ex-ante average life expectancy. By ignoring the longevity differences that characterize our societies, this automatism introduces a regressive redistributive mechanism: more advantaged socio-economic and occupational groups, who in general have a higher life expectancy than the average in the population, receive a pension benefit for a stream of years higher than what is actuarially fair, whereas pensioners who die earlier than the mean will incur a 'waste' of resources.

Are the current improvements in life expectancies reducing these inequalities, or is the socioeconomic gradient widening? Recent years have witnessed an upsurge in research on this question, thanks especially to increasingly available data allowing the construction of long mortality follow-up for different subpopulations and cohorts. 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 and Bosworth 2018 for the US; Baker et al. 2019 for Canada) and from Northern European countries (Mortensen et al. 2015; Tarkiainen et al. 2011; Hann et al. 2020; Zarulli et al. 2012; Bär et al. 2020; Brønnum-Hansen-Baadsgaard, 2012). Some very recent studies have been published on mortality inequalities using data from Spain (González and Rodriguez-González, 2021), Portugal (Costa and Santana, 2021) and Czech Republic (Bertoli and Grembi, 2021). Moreover, most of the quoted studies, although having contributed substantially to the understanding on the evolution of mortality inequalities in previously unexplored countries, have some data driven limitations. They adopt area-level SEP or deprivation indicators, possibly underestimating the social gradients because of higher non-differential misclassification, and present mortality rates adjusted only for age, thus missing the impact on inequality evolution due the changing composition of populations along other dimensions. In the case of Italy, although the socioeconomic mortality differentials have been comprehensively mapped (Leombruni et al. 2015; d'Errico et al. 2017; Lallo & Raitano, 2018; Petrelli et al. 2018; Alicandro et al. 2018; Petrelli et al. 2019), no evidence has been currently published on the evolution of the gradient.

This study aims at contributing to the existing literature along the limits above mentioned. First, we present novel evidence on the evolution over the last 30 years of socio-economic differentials in mortality inequality and in life expectancy at 65 in Italy. Second, thanks to the availability of very rich administrative individual-level data, we can analyse two separate and very accurate measures of SEP rather than aggregated indicators at the area level. Finally, we adjust our estimates with several individual- and job characteristics besides age and gender. All these elements are important for providing estimates on the differential longevity and life expectancy that can inform the debate around the revision of pension eligibility conditions for more disadvantaged categories.

Results indicate that in Italy the gap in life expectancy at 65 by income and occupational groups has increased over time, because of a different rate of growth in life expectancy, which has increased systematically for the advantaged categories while barely improved for the disadvantaged groups. Negative binomial regression analyses and the different sensitivity checks fully confirm the results, showing that mortality inequalities between income groups are widening, controlling for occupational class and for several other individual and work-related characteristics. Inequalities are larger in the regions of North of Italy, in the manufacturing and construction sectors, and in larger firms.

The paper proceeds as follows. The next section describes measures and statistical methods adopted. Section 3 presents the relevant results and section 4 includes robustness checks. In section 5 results are discussed and in section 6 conclusions are drawn.

2. Methods

2.1. Data and Samples

Our primary data come from the administrative archives of the Italian National Institute of Social Security (INPS). INPS data represents the most complete and up-to-date statistical source of information to study mortality differentials between socioeconomic and occupational groups in Italy. It offers 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. Furthermore, the analysis is replicated on an independent information source, the Turin Longitudinal Study (TLS), a longitudinal study based on the historical population register and population census, built to monitor metropolitan health variations linking social and health careers of individuals and families. Turin is one of the four largest cities for population in Italy. For both data sources, it is possible to conduct mortality follow-up by linking administrative records with administrative mortality records up to very recent years, i.e., up to 2019. Advantages of using the TLS are that it allows to test the validity of the results on the population of workers, rather than limited to private sector employees only, and to examine changes in differential life expectancy during a longer time span (as the first census we use dates to 1981).

For the analysis on private workers, the study period was broken down into three 5-year periods: 1990-1994; 1995-1999 and 2000-2004. For each 5-year period, we selected only workers with at least one-month job spell, born in Italy and aged 15-95 at the start of the 5-year period. Individuals were followed until the date of death (recorded at the year-month level) or until the end of the follow-up (equal to 20 years). For example, mortality follow up for workers of the 1990-1994 period went from 1 January 1990 to 31 December 2009 (Table 1). Henceforth the three samples will be referred to as the "1990", "1995" and "2000" samples/cohorts.

***Table 1** Sampling and follow-up (FU) used to construct the analysis sample*

Cohorts	**Start FU** **Start Sampling**	**End Sampling**	**End FU**	**#People (millions)**	**#Years Person (millions)**
«1990»	1st Jan 1990	31st Dec 1994	31st Dec 2009	12.50	245.06
«1995»	1st Jan 1995	31st Dec 1999	31st Dec 2014	12.98	255.11
«2000»	1st Jan 2000	31st Dec 2004	31st Dec 2019	14.22	279.65

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

For each person in the three cohorts, all job spells observed during the relative five-year period were piled. Individual career variables such as 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%). To define weekly wage, we took the sum of reported employment inflation-adjusted earnings divided by the total number of weeks worked and constructed an average weekly wage over the 5-year window for the given cohort. The final analysis dataset is described in Table 2.

As can be seen from Table 2, the composition of the three cohorts 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 sample over time, reflecting the ageing of the working population, and a slight increase in wage levels that is not particularly marked. The change in the composition of sectors is more marked, with an increase of the services sector at the expense of the manufacturing sector, reflecting a general process of tertiarization of the economy. The most striking compositional change evident in Table 2 regards the female sample, that in the 2000 cohort increased by 25% with respect to the 1990 cohort, against a most modest increase experienced by males, coherently with the positive trend of female participation to the labour market.

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

	Men			Women		
Cohorts	1990	1995	2000	1990	1995	2000
Age: at entry	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
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 & Constr.	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
#Persons	7,974,849	8,100,832	8,589,521	4,520,664	4,874,688	5,634,472
% Change w.r.t. 1990		+2%	+8%		+8%	+25%

Notes: Authors' elaboration on Italian Social Security data, INPS, 1990-2019

2.2. SEP Measures

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

As an indicator of income, we used the average weekly wage. Individuals were ranked into quantiles of average weekly wage, which were calculated with cut-off points derived from the final dataset of analysis separately for men and women, and for each time-period.

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 composition or measures definition over time, by looking at category bins of similar size from one year to another. The main analysis is based on income quartiles to guarantee higher bin size.

Occupational social class is categorized according to the European Socio-economic Classification (ESeC) into three categories (Executives, white-collar and blue collar), as the original variable in the INPS data does not allows further disaggregation. This indicator was used in previous studies on life expectancy inequality based on INPS and TLS data (Leombruni et al. 2015; d'Errico et al. 2017), hence it allows an easier comparison and replicability of previous results, although the categorization based on occupational class suffers from changing composition and size over time.

2.3. Data analysis

Specific mortality rates were calculated for five-year age classes, sex, income, occupational class, and cohort 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. Subsequently, we constructed abridged 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 et al (2001), as described by Eayres and Williams (2004).

We examined life expectancy at the age of 65 years. The baseline for age covers the age range from 15 to 95, whereas the observation period is 20 years; consequently, no individual in the samples is really observed from age 15 to ages 95. Only persons who appear with at least a one-month job spell in the five years following the baseline year are included in the study.

To avoid differences in censoring between groups that would bias the analysis (workers followed for the whole study period had a greater chance of experiencing the event, simply because they were followed for longer), we follow all workers for the same length of time, i.e. 20 years in the main analysis and a few years less in the robustness.

Using 5-year age intervals rather than individuals' years of life is standard in adult mortality analysis and 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). Our measure of life expectancy inequality at 65 is the difference between life expectancy at 65 between the top and the bottom SEP category. We estimate standard error and 95% CIs for it assuming that the difference between two life expectancies is normally distributed, as Eayres and Williams (2004) demonstrated that life expectancy is normally distributed even in small samples.

Since estimation of the trend in life expectancy differentials might be biased by omitting variable bias or by labour market compositional changes across years, we complement the life expectancy analysis by running a negative binomial regression model, to estimate mortality rate ratio (MRR) for the lowest-SEP compared to the highest-SEP group, controlling for age (15 categories), cohort (3 categories), region of birth (20 categories), macro-region of work (5 categories), economic activity (11 ISIC rev. 4 categories), work intensity (3 categories: low, mid, high), firm size (3 categories: low, mid, high), occupational class (3 categories), income quantiles (4 categories). To do so, we build individual sociodemographic strata defined by the above-mentioned characteristics and count the number of deaths and person-years at risk within each stratum. All the analyses were stratified by sex.

Since we defined our dependent variable as the total number of deaths events, we initially used a Poisson model. However, since the dependent variable was characterized by overdispersion, a condition arising when the variance of the response variable is greater than the mean, we moved to a negative binomial (NB) model, which incorporates an additional parameter that accounts for the possibility that the conditional variance of the dependent variable may exceed its conditional mean. Overdispersion in fact represents a problem for the Poisson approach, since estimates are inefficient and biased downward (Cameron and Trivedi, 1986).

As in classical Poisson, NB models the expected number of events (deaths, Y) as function of known covariates X_k and the time at risk measured in person years (py). The estimated negative binomial regression coefficient b_k indicates by how much the log of the expected count of deaths (technically, the death rate) varies due to a unitary change of X_k, holding constant the remaining vector of sociodemographic characteristics shared by individuals within each cell. This strategy allows us to assess the effects of our main measure of SEP controlling for the second measure of SEP and for several other individual and career characteristics.

We will first test the presence of social inequality in mortality by income quartiles ($IncomeQ_k$) by estimating the following equation separately by sex:

$$\text{Eq. (1)} \qquad E[Y] = exp\ (b_0 + \sum_{k=1}^{4} IncomeQ_k + X + log\ (py)\ )$$

Where the vector of controls X includes occupational class (3 categories), age (15 categories), cohort (3 categories), region of birth (20 categories), macro- region of work (5 categories), economic activity (11 ISIC categories), work intensity (3 categories), firm size (3 categories).

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

Eq. (2) $$E[Y] = exp\ (b_0 + \sum_{k=1}^{3} IncomeQ_k * \sum_{i=1990}^{2000} year_i + X + log\ (py)\ )$$

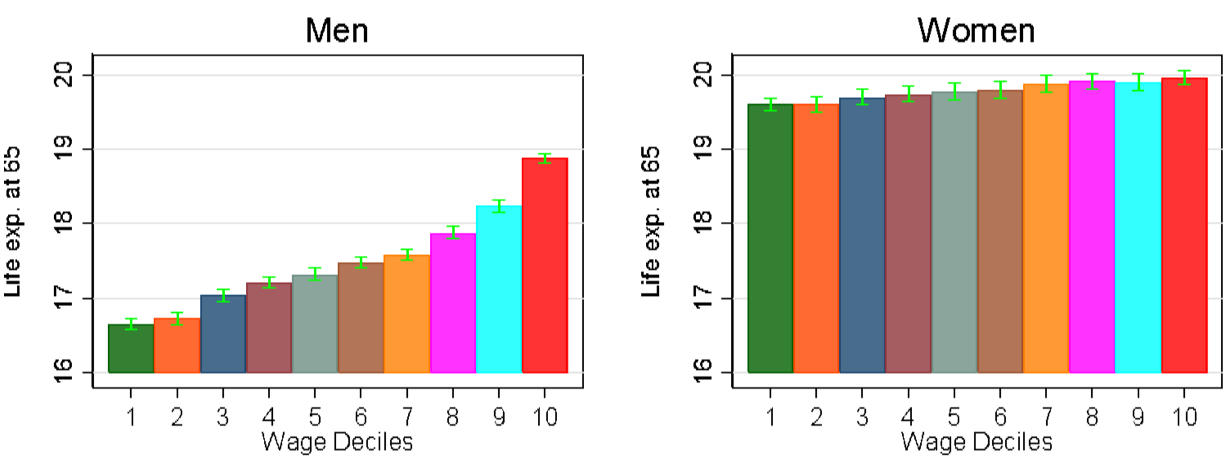
Sensitivity analyses were conducted using a different administrative data source covering the entire working population (private and public sectors), comparing different measures of SEP, extending the periods covered by the analysis and using different sample specifications (see Section: "Robustness").

3. Results

3.1. Life expectancy in Italy

Figure 1 plots life expectancy (and 95% Cis) at age 65 in Italy by income decile, calculated separately for males and females, for the 2000 cohort of workers, the most recent among the three taken into analysis. Several elements confirm the results on social mortality differentials highlighted in the previous literature. A direct socio-economic gradient in life expectancy is present in both sexes, steeper for men than for women. Among male private sector employees belonging to the 2000 cohort, 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 four months.

Figure 1** **Life expectancy at 65 and 95% CIs by income and sex, 2000 cohort

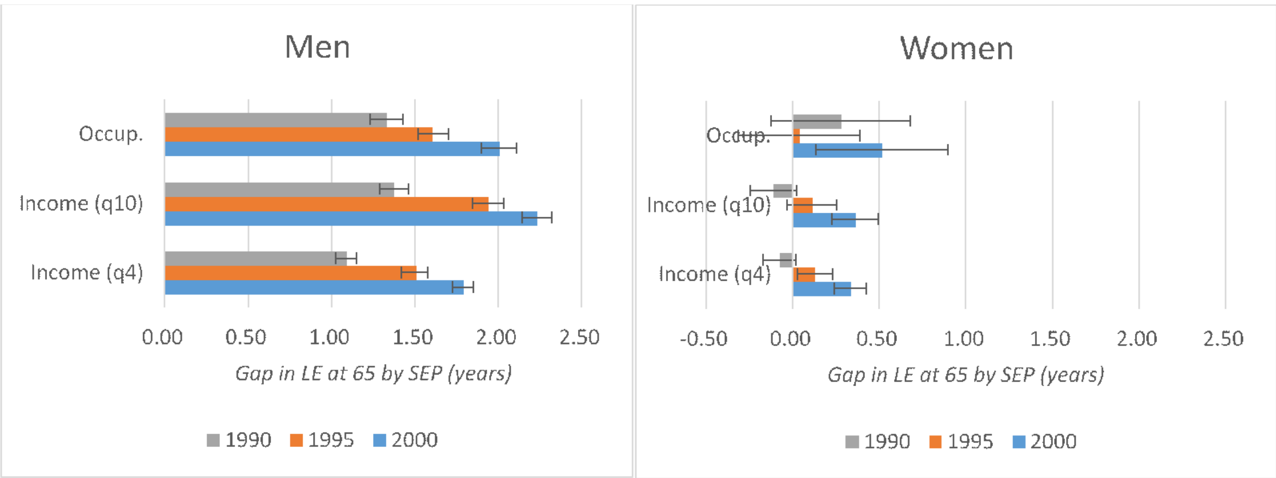


Source: Authors' elaboration on Italian Social Security data, INPS, 1990-2019. *Mortality follow-up is 20 years.*

A similar pattern emerges when using as SEP indicator the occupational social class (Appendix Table 4, panel A). Although occupational social class ranks individuals only in three broader categories (executives, white-collar, blue-collar), the highest SEP group presents a life expectancy at 65 years 2 years higher than blue-collar workers among men (95% CI 1.90, 2.11) and 0.52 among women (95% CI 0.13, 0.90).

In further analyses we restricted the comparison to the change in life expectancy at 65 between the highest and the lowest income quantiles and occupational classes, in the 1990, 1995 and 2000 cohorts. The results displayed in Figure 2 show that social inequality in life expectancy has increased with time, regardless the indicator adopted and in both sexes. Starting from income, we find that among men the life expectancy disadvantage experienced by people in the least 25% of the income distribution increased by about 64% over the last 30 years, raising 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, we find insignificant difference in life expectancy at 65 between the richest and the poorest quartile in 1990 (95% CI: -0.17, 0.02) and a small but significant advantage of about 2 and 4 months of life expectancy for the richest quartile in the 1995 and in 2000 cohort, respectively; these results confirm the presence of a trend of increasing life expectancy inequality also for female private sector employees, although of a lower size.

Figure 2 Trend in difference in life expectancy at 65 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 (q10), income deciles. Income (q4), income quartiles.

We observe very similar results using the prevailing occupational class as indicator of SEP, to those obtained by classifying workers according to income. As shown in Figure 2, among men aged 65 years old, executives could expect to live 1.33 years more than blue collars in 1990 (95% CI 1.23, 1.43) and 2.0 years more in 2000 (95% CI 1.90, 2.11). Although very imprecisely estimated, also among women it is possible to detect a significant difference in life expectancy of about 0.5 years to the advantage of executives in the 2000 cohort.

In Table 4 in the appendix, we present in detail also the absolute changes in life expectancy for all SEPs, to assess whether – although with a different pace – there have been improvements in life expectancy across all population segments. For both men and women and for all the SEP measures used, a gain in life expectancy from the 1990 to the 2000 cohort is present only among highest- a mid-SEP, while it is almost absent for lowest-SEP workers.

3.2. Regression analysis

Table 3 presents mortality rate ratios (MRRs) and 95% CIs from negative binomial regression models for all-cause mortality in the 1990, 1995 and 2000 cohorts. Results from model 1 (based on Equation 1) demonstrate that there were significantly more deaths in the lowest-income groups (Q1) and in the lowest occupational class (Blue-collar) controlling for period, age, region of birth and several work characteristics, and mutually adjusting for the two dimensions of SEP. Among men, lowest-income and blue-collar workers exhibit mortality rate 1.57 and 1.47 times higher compared to the highest-income group and to executives, respectively. For women, the mortality rate ratio among the poorest income group individuals was 1.10, compared to the high-SEP group. Hence, both 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[5]. Thus, according to model 1, the net effects of disadvantaged social status, as measured by having lower income and being blue-collar, placed an individual at a greater risk of dying throughout the study period.

[5] In model 1, the inclusion of occupational class lowers the MRR associated to low-income (Q1) by about 12% for men and 3% for women.

Table 3 ***Mortality Rate Ratios from Negative Binomial Regression Model, by sex***

	Men		Women	
	Model 1 MRR [95% CI]	Model 2 MRR [95% CI]	Model 1 MRR [95% CI]	Model 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

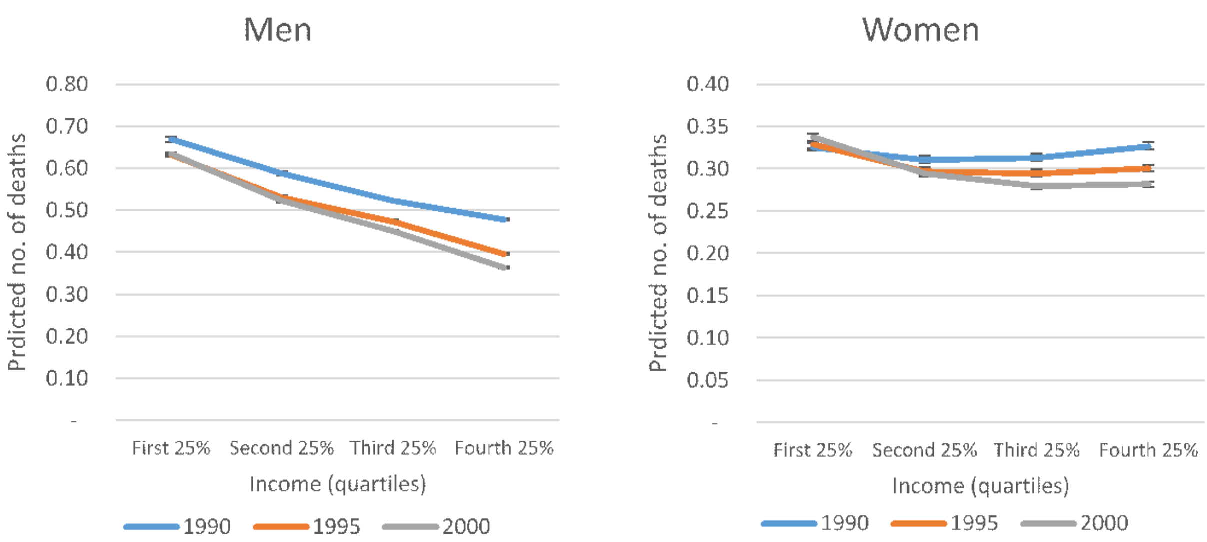
Notes: The table displays MRR from Eq. 1 and 2. Models 1 and 2 are also adjusted for age (15 categories), region of birth (20 categories), macro- region of work (5 categories), economic activity (11 ISIC categories), work Intensity (3 categories: low, mid, high), firm size (3 categories: low, mid, high). Source: Authors' elaboration on Italian Social Security data, INPS, 1990-2019. Mortality follow-up is 20 years.

†p < .10; *p < .05; **p < .01; ***p < .001

In model 2, we investigated the presence of a trend in social inequality in mortality by substituting the income SEP variables with the interaction terms Year*SEP to model 1. Examination of these interactions allowed understanding to what extent the SEP-mortality association differed significantly across the three periods. Results from model 2 show a clear social gradient for men and indicate that a low-income man from the 1990 cohort had 40% higher death rate than highest-income group compared with 60% and 74% higher death rate in the 1995 and 2000 periods, respectively. Because the MRRs for the three interaction terms are significantly above 1.00 and confidence intervals do not overlap, our findings are consistent with the findings from the life expectancy analysis, indicating that the SEP-mortality association became stronger in the most recent cohort. For women, there is some evidence that longevity inequality increased with time too. Whereas in the 1990 cohort there was no disadvantage for low-income persons, we find 9% and 20% greater death rate among low-income compared to high-income women in the 1995 and 2000 cohorts, respectively.

To further explore our key findings, we employed results from model 2 to predict the predicted standardized number of events (deaths) for each income group and year, separately for men and women (Figure 3).

Figure 3 Trend of Standardized Predicted Number of Deaths from Negative Binomial Regression Model (Model 2), by Income Quartiles and Sex



Notes: Predicted number of events from Negative Binomial Regression (Model 2). 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.

While for men the predicted number of deaths exhibits a clear socioeconomic gradient, with deaths decreasing as income increases, for women a flatter but significant gradient starts emerging only in the most recent cohorts, coherently with what emerged from the life expectancy analysis. Furthermore, in both men and women, the distance between the plotted 1990 and 2000 lines, can be interpreted as an indication of by how much the predicted number of events reduced with time. Since the distance is narrowest for the lowest 25% of the income distribution and widens when income increases, Figure 6 suggests that high-income groups experienced a more marked reduction in death rate than low-income groups. This is striking for women, for whom we find no improvement at all in the mortality experience among the poorest 25% while a significant reduction in the death rate occurred for the top income group.

4. Robustness

To test the robustness of results we have performed several checks.

First, we have chosen to replicate the life expectancy analysis on a different source of information on social differences in mortality in Italy, i.e., the TLS. TLS is a prospective study of mortality among persons residents in Turin (the fourth largest city of Italy) censused at the 1981, 1991 and 2001 national population census. Since it deals with all population of Turin, the study offers large numerousness (on average one million of individuals over the three censuses) and it allows to observe the phenomenon on all social strata and not only on those represented by the population working in the private sector. Moreover, TLS has more retrospective depth than the INPS source, since it can observe temporal variations in longevity inequality starting from the 80s, i.e., one decade ahead the time periods covered by the main analysis.

The TLS design consists of a longitudinal study based on *record linkage* between deaths recorded in the National Deaths (and Causes of Deaths) archives from 2000 to 2019 and the 1981, 1991 and 2001 Census archives. Mortality follow-up is 19 years, one year less than in the main analysis. The SEP variables used is occupational social class, based on self-reported data of position in the profession, reclassified into four groups: 1) bourgeoisie (entrepreneurs, executives, highly skilled professionals), 2) middle class (clerical workers), 3) petite bourgeoisie (autonomous artisans and traders, with and without employees), and 4) working class (skilled and unskilled workers). Analysis of mortality by income groups is not possible as the variable is not available in the data.

We find for men significant social inequalities in life expectancy at 65 years that increase with time (Figure 4 in the Appendix). The disadvantage in years between the lowest and the highest occupational class was 0.64 in 1981 (95% CI 0.31, 0.96), 1.22 in 1991 (95% CI 1.06, 1.38) and

1.50 in 2001 (95% CI 1.18, 1.80), thus largely confirming the main findings of the paper. For women, no significant differences in life expectancy emerge in TLS data in all the years, hence undermining the hypothesis that longevity inequality is a recent and emerging phenomenon also for female workers, at least when the reference population also encompasses the public sector (Figure 4 in the Appendix).

Secondly, a possible concern is that the SEP measures used in the main analysis, defined as the prevalent SEP looking at 5 years of potential job spells, do not accurately summarize workers' social conditions, which might have changed over time. However, if we construct the SEP variables using information from 15-years of working career, selecting individuals who were present in all the three cohorts, the estimated gap in life expectancy at 65 years between lowest-SEP and highest-SEP is quantitatively the same as in the main analysis for both men and women. Results are shown in table 5 in the Appendix.

Third, we have extended the life expectancy analysis to more recent cohorts of workers to increase 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 (rather than 20). The results displayed in Figure 6 in the Appendix confirm the overall results, showing that the disadvantage in life expectancy at 65 years for the lowest income groups is raising with time.

Furthermore, negative binomial regression results are also robust to different sample and model specifications. The exclusion from the samples of individuals with very low labour market attachment (i.e., who worked less than 20% of time at baseline); with age<45 at baseline; outliers in income (outside first and 99th percentile) and domestic migrants, leaves the results very similar to the estimates from main analysis, both qualitatively and quantitatively (Table 6 in the Appendix).

Finally, we investigate the presence of heterogeneity in longevity inequality by running a set of separate negative binomial regression fully adjusted models (Eq. 1) on different subpopulations. Figure 5 in the Appendix reports the MRR for lowest- compared to highest-income quartile and shows that mortality inequalities are larger in the North of Italy, in the primary and secondary sectors, and among workers employed in large firms. The pattern is similar among men and women.

5. Discussion

This paper revealed an increasing gap in life expectancy at 65 between income quartiles and occupational classes. By following three cohorts of workers employed in Italy during 1990-1994, 1995-1999 and 2000-2004 for 20 years, our analysis showed that the gap in life expectancy at 65 between the highest and the lowest income quartile widened by 0.7 years among men and 0.4 years among women. In the most recent cohort, remaining life expectancy at age 65 for lowest-income quartile individuals was approximately 1.8 years less than that for highest income individuals among men, and the corresponding gap was 0.33 years for women. Negative binomial regression analyses confirm the overall results. Individual income and occupational class are about equally and independently strongly associated with mortality risk for men and women, conditional on age and sectorial composition, individual region of birth and work, firm size, and work intensity. In the fully adjusted model, we find that lowest income quartile and occupational class individuals exhibit about 60% and 10% higher mortality rate (among men and women, respectively) than the top income and occupational class and that inequality in mortality has significantly amplified with time.

An important strength of our study was that both SEP and death rate were highly accurate since they were derived from administrative data, covering the entire population of private sector workers hence with large sample size and providing measures that are robust to reporting bias or loss to follow up.

We used individual-based SEP measures, which solve the problem of selective migration (Chetty et al. 2016) and potential misclassification of individual exposure and underestimation of the social gradient in mortality generally found with SEP measures based on aggregated geographical areas.

Ranking individuals along income quantiles offers the advantages of limiting problems related to changing composition, definitions, shrinking, or growing groups over time, by always looking at category bins of similar size from one year to another.

A limitation of our SEP indicators is that they are measured in one single point in time, looking at only a 5-year window. However, our sensitivity analysis showed that extending the window to 15-years leaves the results qualitatively and quantitatively similar.

Similar to us, several other scholars reported an increasing gap in life expectancy between the highest and the lowest income among men (Blakely et al. 2005; Tarkiainen et al. 2011; Haan, et al 2020, Brønnum-Hansen and Baadsgaard 2012; Kalwij et al 2013; Chetty et al. 2016), a result which has been confirmed also using different SEP measures, such as area-level income (Currie and Schwandt 2016; Bär et al. 2020), occupational class (Martikainen et al. 2007; Bengtsson et al. 2020), and education level (Brønnum-Hansen and Baadsgaard 2012; Cutler, et al. 2011). However, most of previous findings come from Nordic European countries, New Zealand, and the US, while none have focused on Italy. Furthermore, several previous studies assessed inequality in mortality by SEP groups adjusting only for age and sex, while we were able to provide estimates of the effect of income quantiles controlling for several individual and contextual factors and, importantly, a second SEP dimension simultaneously, i.e. occupational social class.

Previous literature largely supports the results of women's smaller longevity inequalities than men (for example Mustard and Etches, 2003; Currie and Schwandt, 2016, Bengtsson et al. 2020). In contrast, evidence on the trends of female longevity inequality is less clear cut. Some studies show an increase in the female life expectancy gap between highest and lowest SEP over time, although of a smaller magnitude than what observed among males, coherently with our results (Brønnum-Hansen and Baadsgaard 2012; González & González 2021; Costa & Santana). In contrast, a slightly narrowing gap has been reported for women in New Zealand (Blakely et al 2005), while a Swedish study found that the social gradient emerged earlier for women than for men and became equally stronger for both sexes (Bengtsson et al. 2020). In our study the mortality gradient for women was absent in the nineties and emerged more clearly only in the 2000s, years characterized by higher female employment rates. Hence, this finding seems to point to that, in years in which the share of women with gainful employment was low, for women living in couple their own income or occupational social class was unlikely to be a valid indicator of their actual social position, whereas household income or highest class within the couple would be more appropriate (Bengtsson et al. 2020).

The presence of a gap among female in life expectancy at 65 between the highest- and the lowest-SEP was not confirmed when we replicated the analysis on TLS data, a census-based study including all social strata and types of work. This seems to suggest that for women the inclusion of workers from public sector, offering arguably more protection and better conditions, may have diluted the small differential longevity that has emerged among female private sector workers.

The analysis of absolute changes in life expectancy at 65 revealed that for individuals in the bottom income quartile or in the lowest occupational class life expectancy hardly changed over time. The negative binomial fully adjusted model also supports this conclusion, showing that lowest-SEP individuals experienced only a negligible reduction in mortality rate over the observed period. Evidence of stagnation of life expectancy among the most disadvantaged categories was found also in the Finnish general population (1988-2007, LE at 35 by income quintiles, Tarkiainen et al. 2011), in the US (Currie & Schwandt, 2016) and in Germany by Haan et al. (2020) who, similarly to us, focused on life expectancy at 65 by income quantiles, and point to the quicker improvement in life expectancy for top deciles as the main driver of the raise in mortality inequality.

Some studies point to increasing alcohol-related mortality in the working-age population as the main reason for the stagnation of life expectancy in the lowest income quintile (Tarkiainen e al 2011), cardiovascular diseases (Zarulli et al. 2012, Bär et al. 2020, Tarkiainen e al 2011 for men only), cancers (Zarulli et al. 2012) and smoking-related diseases (Currie and Schwands 2016; Fenelon and Preston, 2012). For Italy there is no evidence on the contribution of specific causes of death and this remains an important gap in understanding what the drivers are for longevity inequalities found in Italy.

Italy was severely hit by the Great Recession and the European sovereign debt crisis, experiencing economic dip and negative GDP growth for a longer period compared to other countries and impressive negative effect on the labour market. Whereas at the beginning of the crisis Italy counted 23.1 million employed workers, the same number was roughly reached only at the end of 2019 after having fallen to a minimum in 2013 since the crisis started. Mass employment loss and firms closures persisting for several years have plausibly affected the Italian workforce composition and our results can be partly driven by the worst economic and labour market conditions faced by the most recent cohorts of workers who might have suffered from relatively higher job loss, unemployment, and psychological distress. The unfavourable economic conditions following the 2008-2009 crisis have been shown to have increased mental distress, suicidal mortality (Parmar et al. 2016) and avoidable mortality due to health spending cuts (Arcà et al. 2020) and might have contributed to exacerbate the longevity inequality if they had a differential impact on all-cause mortality, although evidence on this respect is mixed (Borrell et al. 2020; Palència et al. 2020).

6. Conclusion

Despite ample empirical evidence demonstrated a socioeconomic health gradient among adults, empirical research on its evolution is still scarce and less consistent.

This study shows that in Italy, a lower socioeconomic status is associated with a lower life expectancy. This difference is smaller among women than among men, and smaller in the South than in the North, and in the services than in the primary and secondary sectors. However, it turns out to be a transversal and persistent feature of our society.

The study also shows that longevity inequalities have widened over time, due to a different pace of growth in life expectancy and reduction in death rate, which have changed in more favorable manner for the more advantaged categories.

Our results have also distributional implications for the pension system. As several studies have documented, life expectancy inequality translates into inequality of pension entitlements, since individuals who have a lower life expectancy will receive pensions for a shorter period. Since most disadvantaged categories have lower life expectancies, this has regressive implications. Hence, it is important for welfare policy to strive to find ways and means of establishing pension rules that consider differential longevity, which manifests itself in two distinct ways. The first is in terms of level, the most disadvantaged categories have a lower life expectancy. Secondly, it must be acknowledged that life expectancies evolution over time is not the same for everyone, as shown by the recent literature we reviewed and by the results we obtained in this study. Both are fundamental elements to be reconsidered in a pension system in which, as in Italy, there is an automatic increase of the age eligibility requirements according to the average improvement of life expectancy, an adjustment which is hence being applied also to social groups whose life expectancy is currently stagnating.

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and material

The data that support the findings of this study are available from the Italian Institute of Social Security (INPS) and from the Epidemiology Unit ASL TO3 but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the INPS through the VisitINPS Scholars Program (https://www.inps.it/dati-ricerche-e-bilanci/attivita-di-ricerca/programma-visitinps-scholars) and at the Epidemiology Unit ASL TO3 on reasonable request and under restrictions and ad-hoc license use.

Competing interests

The authors declare that they have no competing interests

Funding

The present study was partly funded by the Italian Ministry of Health (project n. RF-2016-02364270, awarded to Giuseppe Costa) and the INPS VisitINPS Scholars Program (Awarded to Chiara Ardito). The funding bodies had no role in the design of the study and collection, analysis, and interpretation of data and in writing the manuscript.

Authors' contributions

CA, together with RL, AdE, GC designed the study. CA, together with NZ contributed to the implementation of the research and data analysis. CA wrote the first draft of the manuscript. All authors contributed to the interpretation of results and to the final version of the manuscript. All authors read and approved the final version of the manuscript.

Acknowledgements

We thank the INPS and the INPS staff for making the data available through the VisitINPS Scholars Program. The authors would like to thank Prof. Fulvio Ricceri (University of Torino) who provided helpful comments and suggestions.

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Appendix

Table 4 Trend in Life expectancy at 65 by SEP and sex

Panel A: LE at 65 by Occupational Social Class (1=blue-collar, 2=white-collar, 3=executives)

Cohort	SEP	LE at 65	95% LB	95% UB	Abs. Change LE_{2000}-LE_{1990}	% Change
			WOMEN			
1990	1	19,55	19,51	19,60		
1995	1	19,64	19,59	19,69		
2000	1	19,74	19,70	19,78	0,19	1,0%
1990	2	19,58	19,51	19,64		
1995	2	19,76	19,69	19,83		
2000	2	19,92	19,86	19,98	0,34	1,7%
1990	3	19,83	19,43	20,23		
1995	3	19,68	19,33	20,03		
2000	3	20,25	19,87	20,63	0,42	2,1%
			MEN			
1990	1	17,01	16,98	17,04		
1995	1	17,22	17,19	17,25		
2000	1	17,31	17,29	17,34	0,30	1,8%
1990	2	17,51	17,46	17,55		
1995	2	18,02	17,97	18,07		
2000	2	18,40	18,36	18,45	0,89	5,1%
1990	3	18,34	18,24	18,43		
1995	3	18,82	18,73	18,91		
2000	3	19,32	19,22	19,42	0,98	5,3%

(Cont.)

(Cont. Table 4)

Panel B: LE at 65 by Income Quartiles						
Cohort	**SEP**	**LE at 65**	**95% LB**	**95% UB**	**Abs. Change LE_{2000}-LE_{1990}**	**% Change**
			WOMEN			
1990	1	19,57	19,51	19,63		
1995	1	19,61	19,54	19,67		
2000	1	19,61	19,55	19,68	0,04	0,2%
1990	2	19,63	19,54	19,72		
1995	2	19,7	19,61	19,78		
2000	2	19,76	19,69	19,82	0,13	0,7%
1990	3	19,62	19,54	19,71		
1995	3	19,69	19,6	19,77		
2000	3	19,83	19,76	19,9	0,21	1,1%
1990	4	19,49	19,42	19,56		
1995	4	19,74	19,66	19,81		
2000	4	19,95	19,88	20,01	0,46	2,4%
			MEN			
1990	1	16,63	16,58	16,67		
1995	1	16,72	16,67	16,77		
2000	1	16,77	16,72	16,81	0,14	0,8%
1990	2	16,84	16,79	16,9		
1995	2	17,18	17,12	17,24		
2000	2	17,22	17,17	17,27	0,38	2,3%
1990	3	17,12	17,07	17,18		
1995	3	17,41	17,36	17,47		
2000	3	17,58	17,53	17,63	0,46	2,7%
1990	4	17,72	17,67	17,76		
1995	4	18,23	18,18	18,27		
2000	4	18,55	18,51	18,6	0,83	4,7%

Source: Authors' elaboration on INPS Italian Social Security Data, 1990-2019

Table 5 Life expectancy at 65 and gap between low-SEP (bottom income quartile, Q1) and high-SEP (top income quartile, Q4), by sex

SEP	LE at 65 (95% CI)	Gap in LE at 65 (95% CI)
Panel A: WOMEN		
Q1 only in 2000	19.40 (19.21, 19.59)	0.54 (0.34, 0.74)
Q1 only in 1995, 2000	19.52 (19.34, 19.71)	0.42 (0.23, 0.61)
Q1 in 1990, 1995, 2000	19.68 (19.58, 19.78)	0.26 (0.14, 0.38)
Q4 in 1990, 1995, 2001	19.94 (19.87, 20.01)	Ref. cat.
Panel B: MEN		
Q1 only in 2000	16.65 (16.54, 16.77)	1.96 (1.84, 2.08)
Q1 only in 1995, 2000	16.66 (16.55, 16.77)	1.95 (1.83, 2.07)
Q1 in 1990, 1995, 2000	16.78 (16.69, 16.86)	1.83 (1.74, 1.92)
Q4 in 1990, 1995, 2001	18.61 (18.56, 18.66)	Ref. cat.

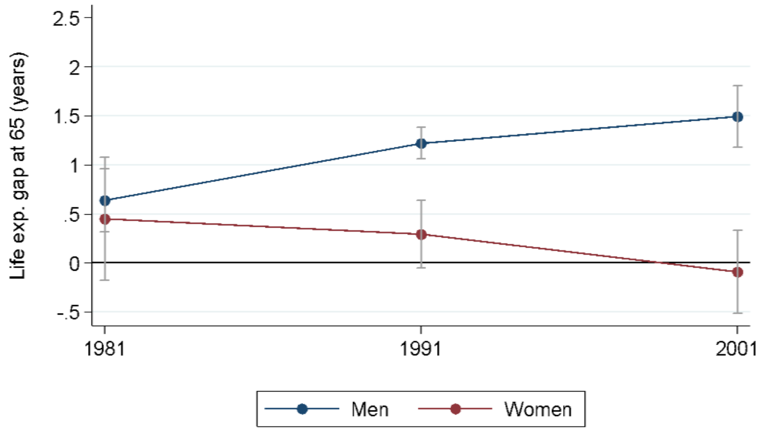
Source: Authors' elaboration on INPS Italian Social Security Data, 1990-2019. Balanced sample, composed of workers present in all the cohorts of 1990, 1995 and 2000. N= 4,734,427 individuals, corresponding respectively to the 55% and 46% of men and women in the unbalanced sample.

Table 6 Mortality Rate Ratios from Negative Binomial Regression Model, by sex and different subpopulations

	Age >45 MRR [95%CI]	At work >20% of time MRR [95%CI]	p1-p99 Income MRR [95%CI]	Domestic Migrants MRR [95%CI]	Domestic Migrants Excluded MRR [95%CI]
Panel A: MEN					
year1990xQ1	1.469***	1.465***	1.419***	1.502***	1.366***
	[1.453,1.485]	[1.448,1.483]	[1.402,1.435]	[1.474,1.529]	[1.348,1.384]
year1995xQ1	1.695***	1.674***	1.589***	1.660***	1.551***
	[1.677,1.713]	[1.654,1.694]	[1.571,1.607]	[1.631,1.689]	[1.531,1.571]
Year2000xQ1	1.856***	1.825***	1.735***	1.785***	1.711***
	[1.837,1.876]	[1.804,1.846]	[1.716,1.754]	[1.755,1.814]	[1.690,1.733]
N	2,534,979	2,217,053	2,679,481	1,851,659	1,200,068
Panel B: WOMEN					
year1990xQ1	1.018	1.014	1.031***	1.041**	0.985
	[0.996,1.040]	[0.991,1.038]	[1.008,1.055]	[1.003,1.081]	[0.962,1.009]
year1995xQ1	1.138***	1.128***	1.110***	1.161***	1.066***
	[1.115,1.162]	[1.103,1.153]	[1.086,1.134]	[1.120,1.202]	[1.042,1.091]
Year2000xQ1	1.246***	1.225***	1.202***	1.238***	1.183***
	[1.223,1.269]	[1.200,1.250]	[1.179,1.225]	[1.199,1.278]	[1.159,1.208]
N	896,169	738,968	964,319	710,869	373,394

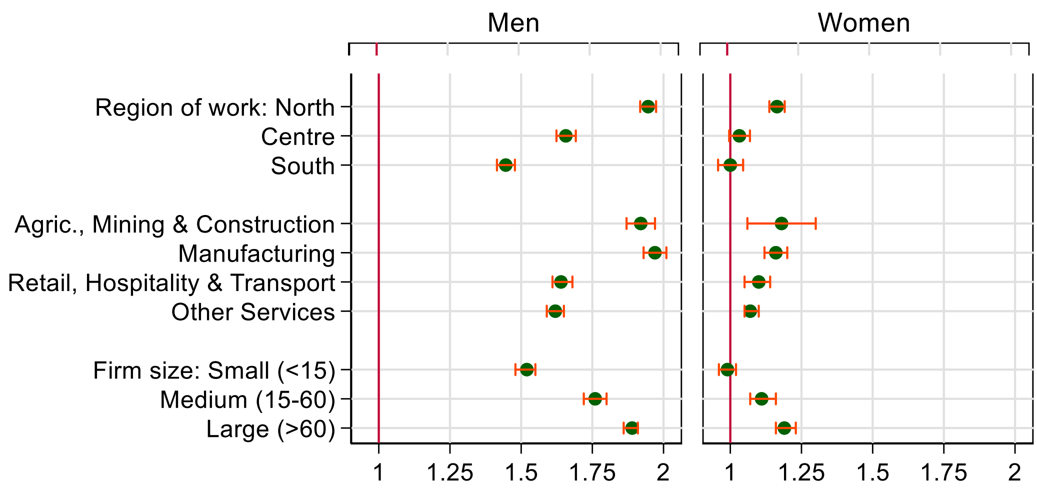
Notes: The table reports MRR from Eq. 2 (Model 2) for being in the lowest income quartile (Q1) versus top quartile, interacted for the year dummy. Models also adjusted for the interactions Q2xYear (3 categories), Q3xYear (3 categories), Year (3 categories), age (15 categories), occupational class (3 categories), region of birth (20 categories), macro- region of work (5 categories), economic activity (11 ISIC categories), work Intensity (3 categories: low, mid, high), firm size (3 categories: low, mid, high). Source: Authors' elaboration on Italian Social Security data, INPS, 1990-2019. Mortality follow-up is 20 years.
*†p < .10; *p < .05; **p < .01; ***p < .001*

Figure 4 Trend in difference in life expectancy at 65 for last and first Occupational Class, by sex



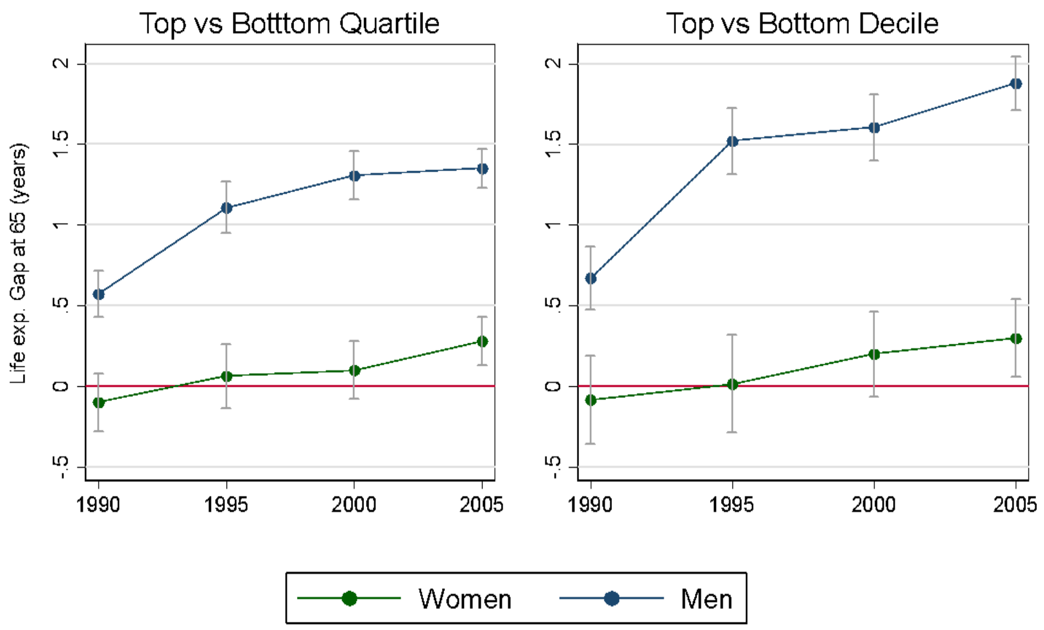
Source: Authors' elaboration on Turin Census Data, TLS 1981-2019. Mortality follow-up is 19 years.

Figure 5 Mortality Rate Ratios from Negative Binomial Regression Model for lowest- compared to highest-income quartile on different subpopulations, by sex (Eq. 1)



Notes: The Figure displays MRR and 95% CI from Eq. 1 run separately on different subgroups and by sex. Models are also adjusted for age (15 categories), region of birth (20 categories), macro- region of work (5 categories), economic activity (11 ISIC categories), work Intensity (3 categories: low, mid, high), firm size (3 categories: low, mid, high). Source: Authors' elaboration on Italian Social Security data, INPS, 1990-2019. Mortality follow-up is 20 years.

Figure 6 Trend in difference in life expectancy at 65 for highest and lowest income quantile, by sex



Source: Authors' elaboration on INPS Italian Social Security Data, 1990-2019. Mortality follow-up is 15 years.