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ORIGINAL ARTICLE

Mortality by occupation-based social class in Italy from 2012 to 2014

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Abstract

Objectives Evaluating socio-economic inequality in cause-specific mortality among the working population requires large cohort studies. Through this census-based study, we aimed to quantify disparities in mortality across occupation-based social classes in Italy.

Methods We conducted a historical cohort study on a sample of more than 16 million workers. We estimated the mortality rate ratios for each social class, considering upper non-manual workers as reference.

Results Non-skilled manual workers showed an increased mortality from upper aero-digestive tract, stomach and liver cancers, and from diseases of the circulatory system, transport accidents and suicides in both sexes, and from infectious diseases, diabetes, lung and bladder cancers only in men. Among women, an excess mortality emerged for cervical cancer, whereas mortality from breast and ovarian cancers was lower. When education was taken into account, the excess mortality decreased in men while was no longer significant in women.

Conclusions There are remarkable disparities across occupation-based social classes in the Italian working population that favour the upper non-manual workers. Our data could be useful in planning policies for a more effective health and social security system.

Keywords Socio-economic inequality · Occupation · Census · Mortality

Introduction

Low socio-economic position is a recognized risk factor for premature mortality from several causes (Mackenbach et al. 2008; Regidor et al. 2016; de Gelder et al. 2017). Multiple mechanisms are involved in the pattern linking low socio-economic position to premature mortality, including risky lifestyle behaviours, reduced access to screening programs, diagnostic procedures and effective treatments, along with psychosocial factors such as stress, depression, financial difficulties, limited social network and low job control, besides possible occupational exposures (Galobardes et al. 2006a).

Occupation-based social classes along with education are the major markers of social standing used in studies investigating socio-economic disparities in health (Galobardes et al. 2006a, b). Two previously published studies found that education is a main determinant of premature mortality in Italy for a wide range of causes with, however, important sex differences, especially when considering cancer mortality (Alicandro et al. 2017, 2018).

Although education and occupation are correlated, they cannot be used interchangeably as they measure different phenomena and act through different mechanisms (Geyer 2006). While education reflects the ability of the individual to turn information into practical measures and behaviours, occupation better indicates prestige, job control and imbalance of effort and reward. All these mechanisms are involved in the generation of socio-economic disparities in health and are expected to have different roles in the

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specific health outcome considered (Peter et al. 2002; Fujishiro et al. 2010).

There is growing interest in evaluating socio-economic disparities in health outcomes among the working population of high-income countries, also considering the impact that they should have in establishing policies for a more effective health and social security system.

This study aims to measure disparities in mortality across occupation-based social classes in the Italian working population. As secondary objectives, we evaluated geographic area and age group differences and we verified if the relationship between occupation and mortality was independent from education.

Methods

This study is a part of an extensive project of the Italian National Institute of Statistics (ISTAT) which aims to investigate socio-economic differences in mortality by linking the 2011 census with the archives of mortality. The project was approved by the Italian Data Protection Authority.

Occupational variables were retrieved from the census. Italian residents were administered two different questionnaires: a short form and a long form. The short form contained only a subset of the census variables, while the long one contained all the census variables, including the occupational variables. The long form was administered to all households living in small/medium municipalities (less than 20,000 inhabitants) and to one-third of the households living in larger municipalities. The households assigned to the long form were selected randomly from the list of residents in the municipality, with each household having the same chance to be selected (Marrone et al. 2011).

The census database was linked with the 2012–2014 mortality archives using the tax code as matching key. Although the census date was the 9 October 2011, we set the start of the follow-up on 1 January 2012 and reconstructed the population at risk at that date by subtracting people who moved abroad and all deaths that occurred between 9 October 2011 and 31 December 2011. This was done as there was a high probability of not being registered in the census for individuals who died in the first three months after the census date. The performance of the record-linkage procedure was excellent, with more than 95% of deaths linked to the census.

The list of residents in all Italian municipalities, in the period 2012–2014, was used to track residents who moved abroad. These individuals were linked with the census and censored at the date of emigration.

Person-years was computed by summing up the period elapsed between the start of follow-up (1 January 2012) and the last date of follow-up (31 December 2014) or date of death or emigration, whichever came first.

This study included all Italian working population aged 20–64 years on 1 January 2012 with available data on occupation (73% of the working Italian population who filled in the long form), while unemployed people and those not in labour forces were excluded. Since it was not possible to define the social class for people working in armed forces, they were not considered in this study.

The Erikson–Goldthorpe (EGP) (Erikson and Goldthorpe 1992) class scheme was used to obtain the social class based on occupation categories. We used the seven-class version, which includes the following categories: upper non-manual workers (professionals, administrators, managers and higher-grade technicians), routine non-manual workers (clerical workers, sales personnel and other rank-and-file service workers), self-employees, farmers (farmers and small holders and other self-employed workers in primary production), skilled manual workers, non-skilled manual workers and agricultural labourers (workers in primary production). To obtain a reliable estimate for people working in the primary production, we regrouped farmers and agricultural labourers in the same social class due to a low number of events.

We used two questions of the long form of the census questionnaire to convert occupation categories into the EGP scheme. These questions asked the subject to indicate his/her occupation and the type of job he/she had in the week that preceded the census date. The first question reflects the major groups of the International Standard Classification of Occupation (ISCO-08) (ILO 2012) and had the following options: (1) non-skilled manual work; (2) personnel working in manufacturing, machinery, assembly lines or drivers; (3) skilled manual work; (4) agriculture and farming; (5) sales and service work; (6) clerical work; (7) medium-qualified technical, administrative, sport or artistic activities; (8) highly qualified activities including management, intellectual, scientific and artistic activities; (9) management of private or public companies and (10) armed forces. The options for the second question were: (1) employee; (2) term contract worker; (3) casual worker; (4) entrepreneur; (5) professional; (6) self-employee; (7) member of a cooperative and (8) family worker. The combination of these two questions was used to assign each subject to one of the EGP categories. The full scheme used to assign the EGP category is reported in Table S1 (electronic supplementary materials).

Age-standardized mortality rates (ASMRs) according to occupation-based social class were calculated using the 2013 European standard population (EUROSTAT 2013).

We derived the mortality rate ratios (MRRs) for each occupation-based social class by fitting a multiplicative quasi-Poisson regression model (Cameron and Trivedi

1998) with log-link function and setting as reference category the upper non-manual workers. The model included also age as 5-year age categories, geographic area and log of person-years as offset variable. Moreover, we run additional models further adjusting for education, to evaluate the independent contribution of occupation-based social class on mortality. The following education levels were considered: no education or primary school, middle school, high school and university. Each model was run separately for sex and for each cause of death.

The main analysis considered mortality from any cause and from wide groups of causes, including infectious and parasitic diseases (International Classification of Diseases, 10th Revision, ICD-10 codes: A00-B99), neoplasms (C00-D48), main cancers (colorectum C20-C21, lung C33-C34, breast C50 and prostate C61), diabetes (E10-E14), all circulatory system diseases (I00-I99), chronic lower respiratory diseases (J40-J47) and external causes (V01-Y98). Moreover, we grouped the causes of deaths according to the contribution that three lifestyle risk factors, i.e. smoking, alcohol and obesity, have on the burden of disease. Each cause was included in one or more of these three groups if the risk factor had a population attributable fraction of at least 20% in high-income countries, as reported by Ezzati et al. (2006).

We carried out a stratified analysis by geographic area of residence (North, Centre, South and major islands) and age group (20–49 and 50–64 years) for mortality from any cause, all neoplasms, all circulatory system diseases, obesity-, alcohol- and smoking-related causes.

Results

The distribution of the study sample on 1 January 2012 according to sex and occupation-based class is given in Table 1. A total of 16,063,872 individuals (9,288,744 men and 6,775,128 women) aged 20–64 were included in this study. The most frequent occupation-based social classes were routine non-manual workers (34.5%), non-skilled manual workers (22.9%) and upper non-manual workers (18.6%). The distribution of occupation-based social class was different between sexes (Chi-squared test p value < 0.0001), with major differences for routine non-manual workers (24.6% men and 48.1% women), self-employees (13.6% men and 6.8% women) and skilled manual workers (16.7% men and 4.3% women). All analyses were performed separately by sex.

Table 2 shows the distribution of number of deaths and ASMRs from any cause, selected groups of causes and main cancers according to occupation-based social class. Corresponding figures for detailed causes, i.e. upper aerodigestive tract (UADT), stomach, liver, pancreatic, skin, cervical, uterine, ovarian, renal, bladder and brain cancers, lymphomas, leukaemias, ischaemic heart and cerebrovascular diseases, transport accidents and suicides, are given in Table S2 (electronic supplementary materials). During the 3 years considered, we observed 42,558 deaths in men and 15,800 in women for any cause, mostly caused by all neoplasms (45% in men and 70% in women) followed by all circulatory system diseases (22% in men and 12% in women) and all external causes (17% in men and 8% in women). The ASMR for any cause was 172.2 deaths per 100,000 person-years among men and 89.8 among women. In both sexes, the lowest mortality rate was observed among upper non-manual workers (ASMR for men 135.4 per 100,000 person-years, ASMR for women 83.9 deaths per 100,000 person-years). Non-skilled men and self-employed women had the highest mortality rate (ASMR 207.2 and 98.1 deaths per 100,000 person-years, respectively).

Table 3 shows the MRRs and corresponding 95% CIs, obtained from two different models, according to sex and occupation-based social class, for any cause, selected groups of causes and main cancers. The "model 1" included age and geographic area as adjustment variables, while the "model 2" was further adjusted for education. In

Table 1 Distribution of the resident population according to occupation-based social class by sex

	Men		Women		Total	
	N	%	*N*	%	*N*	%
Upper non-manual workers	1,669,220	18.0	1,316,247	19.4	2,985,467	18.6
Routine non-manual workers	2,284,572	24.6	3,258,363	48.1	5,542,935	34.5
Self-employees	1,263,077	13.6	461,479	6.8	1,724,556	10.7
Farmers	203,618	2.2	84,137	1.2	287,755	1.8
Skilled manual workers	1,552,170	16.7	288,132	4.3	1,840,302	11.5
Non-skilled manual workers	2,316,087	24.9	1,366,770	20.2	3,682,857	22.9
All levels	9,288,744	100.0	6,775,128	100.0	16,063,872	100.0

Age 20–64 years, Italy, 1 January 2012. Forty-three subjects were not included since they did not report their occupation

Table 2 Number of deaths and age-standardized mortality rate (ASMR) per 100,000 person-years from any cause and selected causes of death, according to sex and occupation-based social class

Cause of death (ICD-10 codes)	Upper non-manual workers		Routine non-manual workers		Self-employees		Farmers		Skilled manual workers		Non-skilled manual workers		Total	
	Deaths	ASMR	Deaths	ASMR	Deaths	ASMR	Deaths	ASMR	Deaths	ASMR	Deaths	ASMR	Deaths	ASMR
Men														
Any cause	6991	135.44	9083	163.12	6966	175.97	1337	199.03	6443	178.80	11738	207.20	42558	172.23
Infectious and parasitic diseases (A00-B99)	144	2.65	198	3.26	139	3.34	23	3.35	134	3.16	297	4.46	935	3.49
All neoplasms (C00-D48)	3428	65.84	4248	79.76	3188	80.30	547	79.25	2929	89.43	4933	93.10	19273	80.76
Colorectal cancer (C18-C21)	393	7.64	459	8.57	341	8.48	53	7.52	287	7.98	441	8.00	1974	8.20
Lung cancer (C33-C34)	689	13.56	947	19.52	779	20.32	111	16.37	736	25.94	1323	27.16	4585	20.42
Prostatic cancer (C61)	81	1.69	65	1.37	58	1.56	7	1.02	39	1.49	65	1.43	315	1.51
Diabetes (E10-E14)	113	2.23	170	3.58	133	3.48	32	4.74	81	2.43	218	4.31	747	3.31
All circulatory system diseases (I00-I99)	1609	30.39	2095	38.31	1617	39.61	308	45.11	1296	36.53	2582	46.55	9507	38.51
Chronic lower respiratory diseases (J40-J47)	34	0.95	39	0.86	35	0.97	7	0.96	30	0.97	89	1.92	234	1.09
All external causes (V01-Y98)	939	19.41	1317	20.10	1113	29.90	265	43.09	1310	29.34	2175	32.13	7119	26.60
Other causes	724	13.97	1016	17.25	741	18.37	155	22.52	663	16.94	1444	24.73	4743	18.48
Women														
Any cause	3200	83.86	6659	90.20	1400	98.08	279	89.69	645	84.34	3617	91.41	15800	89.76
Infectious and parasitic diseases (A00-B99)	26	0.70	103	1.25	22	1.36	5	1.39	10	1.70	48	1.20	214	1.15
All neoplasms (C00-D48)	2361	61.96	4679	63.72	1013	70.75	175	52.88	434	56.26	2341	58.24	11,007	62.43
Colorectal cancer (C18-C21)	224	5.81	354	4.84	89	6.49	18	5.03	37	4.93	210	5.00	932	5.27
Lung cancer (C33-C34)	296	8.30	733	11.25	145	10.18	25	7.09	72	11.29	347	9.09	1618	9.82
Breast cancer (C50)	669	16.41	1199	14.66	247	16.18	32	9.24	81	9.21	472	11.03	2700	14.06
Diabetes (E10-E14)	18	0.49	28	0.45	7	0.57	3	0.90	6	0.90	29	0.90	91	0.60
All circulatory system diseases (I00-I99)	327	8.57	744	11.01	148	10.42	41	11.56	69	9.54	515	13.16	1844	10.82
Chronic lower respiratory diseases (J40-J47)	13	0.37	24	0.42	7	0.53	1	0.25	1	0.34	19	0.45	65	0.42
All external causes (V01-Y98)	217	5.38	560	6.30	98	6.71	27	9.05	66	7.20	320	8.68	1288	6.83
Other causes	238	6.38	521	7.06	105	7.74	27	13.65	59	8.40	345	8.79	1295	7.50

Age 20–64 years, Italy, period 2012–2014

ASMR age-standardized mortality rate, *ICD-10* International Classification of Diseases, 10th Revision

Table 3 Results of the log-linear quasi-Poisson regression models[a] on mortality for group of causes of death, stratified by sex: mortality rate ratios (MRRs) and 95% confidence intervals for occupation-based social class (reference: upper non-manual workers)

Cause of death (ICD-10 codes)		Routine non-manual workers	Self-employees	Farmers	Skilled manual workers	Non-skilled manual workers
Men						
Any cause	Model 1	1.20 (1.15–1.24)	1.31 (1.26–1.37)	1.48 (1.37–1.60)	1.33 (1.27–1.39)	1.56 (1.50–1.62)
	Model 2	1.08 (1.03–1.12)	1.06 (1.01–1.12)	1.18 (1.09–1.27)	1.06 (1.01–1.11)	1.23 (1.18–1.29)
Infectious and parasitic diseases (A00-B99)	Model 1	1.25 (0.94–1.66)	1.25 (0.92–1.70)	1.28 (0.72–2.28)	1.28 (0.94–1.74)	1.89 (1.45–2.46)
	Model 2	1.24 (0.90–1.70)	1.02 (0.72–1.46)	1.03 (0.56–1.91)	1.03 (0.71–1.48)	1.49 (1.07–2.06)
All neoplasms (C00-D48)	Model 1	1.21 (1.15–1.28)	1.23 (1.16–1.30)	1.22 (1.10–1.36)	1.33 (1.26–1.41)	1.44 (1.37–1.52)
	Model 2	1.11 (1.04–1.18)	1.02 (0.95–1.09)	0.99 (0.89–1.11)	1.09 (1.02–1.17)	1.16 (1.09–1.24)
Colorectal cancer (C18-C21)	Model 1	1.14 (0.84–1.55)	1.14 (0.82–1.59)	1.03 (0.54–1.98)	1.13 (0.80–1.61)	1.12 (0.82–1.52)
	Model 2	1.05 (0.73–1.52)	1.04 (0.69–1.57)	0.94 (0.45–1.97)	1.03 (0.66–1.58)	1.01 (0.67–1.51)
Lung cancer (C33-C34)	Model 1	1.42 (1.27–1.59)	1.51 (1.34–1.69)	1.21 (0.96–1.52)	1.82 (1.61–2.05)	2.06 (1.85–2.29)
	Model 2	1.23 (1.09–1.39)	1.11 (0.97–1.26)	0.85 (0.68–1.08)	1.30 (1.14–1.49)	1.44 (1.28–1.64)
Prostatic cancer (C61)	Model 1	0.88 (0.71–1.08)	0.96 (0.78–1.19)	0.65 (0.40–1.05)	0.88 (0.69–1.13)	0.93 (0.76–1.15)
	Model 2	0.82 (0.65–1.03)	0.84 (0.66–1.08)	0.56 (0.34–0.92)	0.77 (0.58–1.01)	0.80 (0.63–1.03)
Diabetes (E10-E14)	Model 1	1.52 (1.17–1.97)	1.57 (1.20–2.07)	2.10 (1.37–3.23)	1.21 (0.88–1.65)	1.99 (1.55–2.55)
	Model 2	1.41 (1.06–1.87)	1.28 (0.93–1.75)	1.64 (1.04–2.59)	0.96 (0.67–1.36)	1.55 (1.14–2.10)
All circulatory system diseases (I00-I99)	Model 1	1.23 (1.14–1.32)	1.32 (1.22–1.43)	1.47 (1.28–1.69)	1.21 (1.11–1.32)	1.53 (1.42–1.64)
	Model 2	1.09 (1.01–1.18)	1.08 (0.99–1.19)	1.19 (1.03–1.37)	0.98 (0.89–1.08)	1.22 (1.12–1.33)
Chronic lower respiratory diseases (J40-J47)	Model 1	1.15 (0.76–1.74)	1.39 (0.91–2.13)	1.51 (0.73–3.15)	1.51 (0.97–2.35)	2.66 (1.85–3.81)
	Model 2	1.04 (0.66–1.63)	0.95 (0.58–1.54)	0.98 (0.46–2.10)	0.99 (0.60–1.65)	1.70 (1.09–2.64)
All external causes (V01-Y98)	Model 1	1.04 (0.95–1.14)	1.56 (1.42–1.71)	2.28 (1.97–2.65)	1.52 (1.39–1.67)	1.71 (1.57–1.86)
	Model 2	0.92 (0.83–1.01)	1.21 (1.09–1.35)	1.75 (1.50–2.04)	1.17 (1.06–1.30)	1.29 (1.17–1.42)
Other causes	Model 1	1.26 (1.08–1.46)	1.35 (1.15–1.58)	1.67 (1.27–2.19)	1.29 (1.09–1.52)	1.79 (1.56–2.06)
	Model 2	1.12 (0.95–1.31)	1.04 (0.87–1.24)	1.26 (0.95–1.67)	0.97 (0.81–1.17)	1.33 (1.13–1.57)
Women						
Any cause	Model 1	1.07 (1.01–1.13)	1.16 (1.07–1.26)	1.03 (0.88–1.21)	1.04 (0.93–1.17)	1.09 (1.02–1.16)
	Model 2	1.03 (0.96–1.09)	1.09 (1.00–1.20)	0.96 (0.81–1.14)	0.97 (0.86–1.09)	1.01 (0.94–1.10)
Infectious and parasitic diseases (A00-B99)	Model 1	1.96 (1.11–3.46)	2.23 (1.06–4.68)	2.35 (0.67–8.23)	1.89 (0.73–4.94)	1.76 (0.94–3.30)
	Model 2	1.50 (0.81–2.80)	1.51 (0.67–3.39)	1.50 (0.40–5.53)	1.20 (0.43–3.35)	1.12 (0.54–2.32)
All neoplasms (C00-D48)	Model 1	1.04 (0.99–1.10)	1.14 (1.05–1.23)	0.86 (0.73–1.02)	0.96 (0.86–1.07)	0.96 (0.90–1.02)
	Model 2	1.02 (0.96–1.09)	1.11 (1.02–1.21)	0.85 (0.71–1.01)	0.93 (0.83–1.05)	0.93 (0.86–1.01)
Colorectal cancer (C18-C21)	Model 1	0.84 (0.69–1.03)	1.06 (0.79–1.42)	0.93 (0.53–1.66)	0.87 (0.57–1.32)	0.90 (0.72–1.13)
	Model 2	0.83 (0.65–1.04)	1.02 (0.73–1.43)	0.91 (0.49–1.67)	0.83 (0.53–1.32)	0.87 (0.65–1.16)
Lung cancer (C33-C34)	Model 1	1.34 (1.14–1.57)	1.26 (1.00–1.59)	0.92 (0.57–1.47)	1.27 (0.94–1.71)	1.13 (0.94–1.35)
	Model 2	1.26 (1.05–1.50)	1.10 (0.86–1.42)	0.78 (0.48–1.27)	1.07 (0.78–1.48)	0.96 (0.77–1.19)
Breast cancer (C50)	Model 1	0.90 (0.83–0.99)	0.98 (0.86–1.12)	0.58 (0.42–0.81)	0.60 (0.49–0.75)	0.67 (0.60–0.74)
	Model 2	0.93 (0.84–1.03)	1.05 (0.91–1.22)	0.64 (0.46–0.90)	0.66 (0.53–0.83)	0.74 (0.65–0.84)
All circulatory system diseases (I00-I99)	Model 1	1.23 (1.03–1.47)	1.22 (0.93–1.58)	1.47 (0.95–2.29)	1.15 (0.81–1.64)	1.55 (1.28–1.86)
	Model 2	1.09 (0.90–1.32)	1.00 (0.76–1.33)	1.16 (0.74–1.83)	0.91 (0.63–1.32)	1.23 (0.98–1.54)
All external causes (V01-Y98)	Model 1	1.01 (0.85–1.19)	1.24 (0.97–1.59)	1.78 (1.18–2.70)	1.31 (0.99–1.75)	1.36 (1.14–1.63)
	Model 2	0.99 (0.82–1.19)	1.19 (0.91–1.56)	1.71 (1.11–2.63)	1.24 (0.91–1.70)	1.29 (1.04–1.60)
Other causes	Model 1	1.13 (0.90–1.41)	1.19 (0.85–1.67)	1.39 (0.77–2.49)	1.31 (0.86–2.00)	1.43 (1.12–1.82)

Table 3 (continued)

Cause of death (ICD-10 codes)		Routine non-manual workers	Self-employees	Farmers	Skilled manual workers	Non-skilled manual workers
	Model 2	1.01 (0.79–1.31)	1.01 (0.70–1.47)	1.14 (0.62–2.10)	1.09 (0.69–1.72)	1.18 (0.87–1.60)

Age 20–64 years, Italy, period 2012–2014. In women, the MRRs were not shown for diabetes and chronic lower respiratory diseases in all occupational classes since the number of deaths were limited

ICD-10 International Classification of Diseases, 10th Revision

[a]Model 1 included the natural log of the number of deaths as dependent variable, 5-year age categories, geographic area of residence and occupation-based social class as independent variables, and log of person-years at risk as offset variable. Model 2 included a further adjustment for educational level

men, all occupational social classes showed a significant excess in mortality as compared to upper non-manual workers from most of causes. Adjusting for education considerably reduced the differences across occupation-based social classes. However, compared to upper non-manual workers, the MRRs remained considerably higher for infectious diseases (MRR 1.49), lung cancer (MRR 1.44), diabetes (MRR 1.55) and chronic lower respiratory diseases (MRR 1.70) among non-skilled manual workers, and for diabetes (MRR 1.64) and external causes (MRR 1.75) among farmers. In women, disparities among the occupation-based social classes were weaker and mostly not significant due to the limited number of deaths. The significant excess mortality from infectious diseases among routine non-manual workers and self-employees that emerged from “model 1” disappeared when adjusting for education. Mortality from breast cancer was lower among farmers, skilled and non-skilled manual workers as compared to upper non-manual workers, also in the model adjusted for education. In contrast, mortality from lung cancer was higher among routine non-manual workers.

Table S3 (electronic supplementary materials) shows the corresponding figures for each detailed cause, and a graphical overview of the MRRs comparing the lowest versus the highest occupation-based social class (i.e. non-skilled vs upper non-manual workers) for selected cancer sites is given in Fig. 1. In men, the cancer sites with the highest disparities between upper non-manual and non-skilled manual workers were UADT (MRR 2.37), bladder (MRR 2.10), lung (MRR 2.06), liver (MRR 1.99) and stomach (MRR 1.62). In contrast, mortality from skin cancer was lower among non-skilled manual workers (MRR 0.74). When adjusting for education, these disparities became smaller for UADT, bladder, lung and stomach cancers, whereas disappeared for liver and skin cancers. In women, non-skilled manual workers had a higher risk of mortality from cervical (MRR 2.15), UADT (MRR 1.84) and stomach (MRR 1.73) cancers. In contrast, for this social class, mortality from breast (MRR 0.67) and ovarian (MRR 0.76) cancers showed a decreased risk. When adjusting for education, these associations remained only for UADT and breast cancers, while pancreatic cancer became significantly associated with lower mortality in non-skilled manual workers. Non-skilled manual workers had also a significant increased risk of mortality from ischaemic heart (MRR 1.56 for men and 1.48 for women) and cerebrovascular diseases (MRR 1.51 for men and 1.60 for women), transport accidents (MRR 1.76 for men and 1.62 for women), with no appreciable sex differences. These associations were no longer significant after the adjustment for education among women. A significant excess mortality from suicide was found among non-skilled manual men (MRR 1.39) that was no longer significant when adjusting for education.

In men, mortality from obesity-, alcohol- and smoking-related causes was higher among all social classes compared to upper non-manual workers, with alcohol-related causes showing the highest risks. In women, non-skilled manual workers had a significantly increased mortality for all the three groups of causes, as well as routine non-manual workers for obesity- and smoking-related causes, self-employees for alcohol- and smoking-related causes, and farmers for obesity and alcohol-related causes (Table 4). When adjusting for education, the excess mortality from these groups of causes weakened in men, while generally disappeared in women with the only exception for obesity-related causes.

Table S4 and Table S5 (electronic supplementary materials) show the results of the stratified analyses for any cause, all neoplasms, all circulatory system diseases, obesity-, alcohol- and smoking-related causes by geographic area and age group. Among men, non-skilled manual workers living in the north showed higher MRRs than those living in other areas of the country. The disadvantage for non-skilled manual workers tended to be greater for the younger age group in both sexes.

Discussion

We found remarkable differences in overall mortality across occupation-based social classes in young and middle-aged Italian working men, while smaller differences

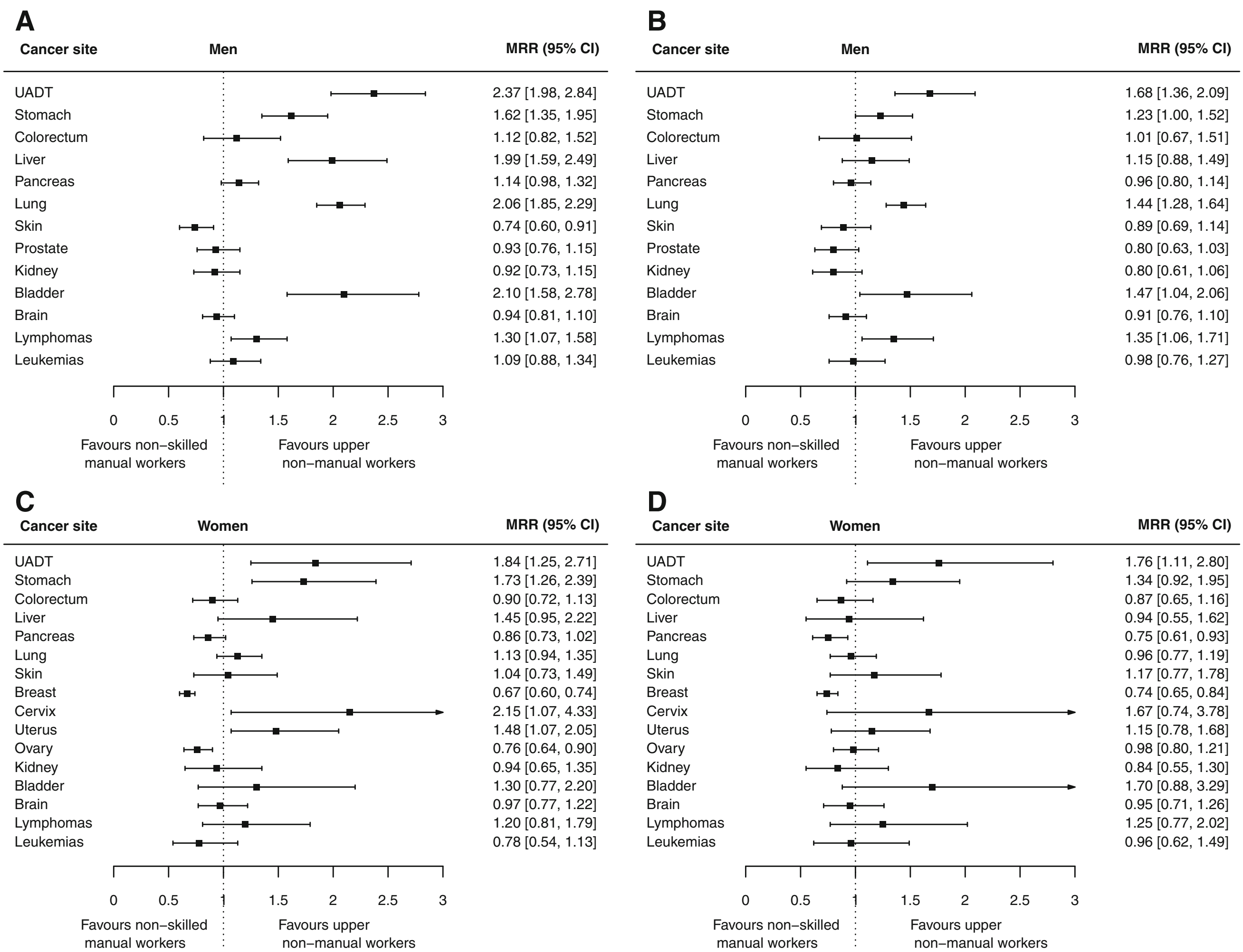

Fig. 1 Mortality rate ratios (MRRs) and 95% confidence intervals (CI) for non-skilled manual as compared to upper non-manual workers by sex and cancer site/type. **a** (men) and **c** (women) show the MRRs obtained from a quasi-Poisson regression models including age and geographic area of residence as adjustment variables. **b** (men) and **d** (women) show the MRRs obtained from models including educational level as further adjustment. Age 20–64 years, Italy, period 2012–2014. *UADT* upper aero-digestive tract

were found in women. These differences weakened in men and were no longer significant in women when educational level was taken into account. The disadvantage for the lower social class tended to be more pronounced in younger people and in those living in northern Italy.

Similar socio-economic disparities were also found in other European populations in the early 2000s. An extensive comparative study (Toch-Marquardt et al. 2014), based on longitudinal data of 14 European male cohorts, showed inequalities in mortality by occupational class, with a social gradient in favour of upper non-manual workers. This inequality was found for mortality from any cause as well as from some broad group of causes, such as all cancers, cardiovascular diseases and external causes. The magnitude of inequality differed across Europe with northern and eastern countries showing larger inequality as compared to southern countries. However, data from southern Europe were not representative of the whole countries since they were collected only in selected urban and generally wealthier areas. However, our results, obtained from the whole Italian population, were similar to those reported in that study for Turin and Tuscany with approximately two-fold increase in mortality (1.7 for Tuscany and 2.2 for Turin) from any cause among non-skilled manual workers as compared to upper non-manual workers.

We found a different pattern of association for breast and ovarian cancers with upper non-manual workers showing an increased mortality. The excess mortality from breast cancer among non-manual workers could be at least partly attributable to the reproductive behaviour of career women, characterized by reduced parity and increased age at first birth, both risk factors for breast cancer (Strand et al. 2007). Moreover, women in the high social class benefit

Table 4 Results of the log-linear quasi-Poisson regression models[a] on mortality for group of causes of death according to lifestyle risk factors, stratified by sex: mortality rate ratios (MRRs) and 95% confidence intervals for occupation-based social class (reference: upper non-manual workers)

		Routine non-manual workers	Self-employees	Farmers	Skilled manual workers	Non-skilled manual workers
Men						
Obesity-related causes[b]	Model 1	1.25 (1.16–1.34)	1.34 (1.24–1.45)	1.52 (1.33–1.73)	1.21 (1.12–1.32)	1.56 (1.45–1.67)
	Model 2	1.11 (1.03–1.20)	1.10 (1.01–1.20)	1.22 (1.06–1.40)	0.98 (0.89–1.07)	1.24 (1.15–1.35)
Alcohol-related causes[c]	Model 1	1.45 (1.26–1.67)	1.65 (1.43–1.91)	2.26 (1.8–2.84)	1.81 (1.56–2.10)	2.42 (2.13–2.76)
	Model 2	1.22 (1.05–1.41)	1.11 (0.94–1.30)	1.46 (1.15–1.85)	1.18 (1.00–1.39)	1.54 (1.32–1.79)
Smoking-related causes[d]	Model 1	1.27 (1.21–1.34)	1.37 (1.29–1.44)	1.46 (1.32–1.61)	1.41 (1.34–1.50)	1.70 (1.61–1.78)
	Model 2	1.12 (1.06–1.18)	1.06 (1.00–1.130)	1.10 (1.00–1.22)	1.08 (1.01–1.15)	1.27 (1.20–1.35)
Women						
Obesity-related causes[b]	Model 1	1.18 (1.01–1.39)	1.23 (0.98–1.54)	1.46 (1.00–2.15)	1.07 (0.78–1.48)	1.54 (1.31–1.81)
	Model 2	1.04 (0.88–1.24)	1.01 (0.79–1.29)	1.15 (0.77–1.70)	0.85 (0.61–1.19)	1.22 (1.00–1.49)
Alcohol-related causes[c]	Model 1	1.21 (0.94–1.57)	1.72 (1.23–2.40)	1.98 (1.16–3.39)	1.54 (0.99–2.39)	1.66 (1.28–2.17)
	Model 2	1.07 (0.80–1.42)	1.41 (0.98–2.05)	1.56 (0.88–2.74)	1.21 (0.75–1.96)	1.31 (0.95–1.82)
Smoking-related causes[d]	Model 1	1.23 (1.06–1.43)	1.29 (1.04–1.60)	1.14 (0.75–1.72)	1.22 (0.92–1.64)	1.32 (1.12–1.56)
	Model 2	1.11 (0.94–1.31)	1.08 (0.86–1.37)	0.93 (0.61–1.41)	1.00 (0.73–1.35)	1.08 (0.89–1.32)

Age 20–64 years, Italy, period 2012–2014

[a]Model 1 included the natural log of the number of deaths as dependent variable, 5-year age categories, geographic area of residence and occupation-based social class as independent variables, and log of person-years at risk as offset variable. Model 2 included a further adjustment for educational level

[b]This group includes diseases of the circulatory system (International Classification of Diseases, 10th Revision, ICD-10 codes: I00-I99), diabetes (E10-E14) and cancer of uterus (C54-C55)

[c]This group includes alcohol abuse (ICD-10 codes: F10), cirrhosis, chronic hepatitis (K70-K74), upper aero-digestive tract (C00-C14, C15, C32) and liver (C22) cancers

[d]This group includes circulatory system (ICD-10 codes: I00-I99) and chronic lower respiratory diseases (J40-J47), lung (C33-C34), upper aero-digestive tract (C00-C14, C15, C32), stomach (C16), liver (C22), pancreas (C25) and bladder (C67) cancers

from early diagnosis (Damiani et al. 2012) and better survival (Sprague et al. 2011) even in countries with universal health systems and implementing population-wide screening programmes (Buzzoni et al. 2011; Carrozzi et al. 2015). Reproductive risk factors may have also played a role in increasing the incidence of ovarian cancer among upper non-manual workers (La Vecchia 2017), while survival data showed contradictory results (Poole et al. 2016).

A multicohort study and meta-analysis (Stringhini et al. 2017) of 48 cohorts from seven World Health Organization (WHO) countries (UK, France, Switzerland, Portugal, Italy, USA and Australia) found that the independent association between occupation-based social class and mortality is comparable in magnitude to that observed for some risk factors such as high alcohol drinking, physical inactivity, hypertension, diabetes and obesity, and smaller only to tobacco. This association was found in both sexes when looking at the pooled estimates, while was not observed in women enrolled in the Italian European Prospective Investigation into Cancer and Nutrition (EPIC) cohort, a population-based cohort, and in women included in the Work History Panel (WHIP) cohort, a sample of Italian workers employed in the private sector in the period 1985–2010.

Several socio-economic classifications based on occupation have been developed. The UK's National Statistics Socio-economic Classification (NS-SEC), the European Socio-economic (ESeC) and the EGP classification are among the most frequently used tools to determine the social standing in Europe. However, the NS-SEC and the ESeC require information on the company size and supervisory role that we did not collect in the Italian census, while we were able to assign an EGP class to each individual on the basis of the working relationship and occupation.

The EGP scheme has a strong theoretical basis, but it does not have a hierarchical structure; consequently, it cannot detect a gradient in health outcomes that was instead previously reported in other studies by using the ESeC classification (D'Errico et al. 2017). However, we adopted the EGP scheme as it has been used in previous studies aiming to compare socio-economic inequality across Europe (Mackenbach et al. 2003; Toch-Marquardt et al. 2014).

The basic concept behind the EGP scheme is that individuals within a social class share similar lifestyles and hold similar life chances (Connelly et al. 2016). In fact, a more favourable pattern of healthy behaviours is likely to explain, at least in part, the reduced mortality found among upper non-manual workers along with more material resources and opportunities to get early diagnosis and better treatments (Verlato et al. 2014; Mackenbach et al. 2015). Psychosocial factors at work, such as high prestige, control and autonomy, may have also contributed to the reduced risk among the higher social classes (Backé et al. 2012; Pikhart and Pikhartova 2015). On the other hand, increased risk of work-related injuries and job exposure to toxic substances and physical stress may have increased the risk of some lower occupational classes, such as the manual workers and farmers.

In addition, our results support the concept that education and occupation are not interchangeable as markers of socio-economic status (Geyer 2006). In fact, we were able to quantify the net effect of occupation on mortality showing that after adjusting for education there is still a part of the effect unexplained.

The large cohort with more than 16 million Italians is the major strength of this study since it allowed to quantify disparities across occupation-based social classes for a wide range of causes of death. Moreover, since there are no national data so far, it provides unique and representative data to be used for international comparisons.

The study has also some limitations. We could not consider the job loss, occupational mobility and professional career since data on occupation were collected only once at census. Thus, some individuals may have lost or changed their job over the follow-up, although most job changes were likely within the same or similar EGP category. Moreover, people experiencing a favourable occupational move have a reduced risk of mortality as compared to their counterparts who remained in their job (Cambois 2004). However, this limitation is unlikely to have affected our estimates, as occupational data were collected quite close to the event as the study covered all deaths observed over a 3-year period. In addition, we could not evaluate the contribution of lifestyle risk factors on the socio-economic disparities in mortalities since this information was not collected in the census.

As for the 2011 census sampling plan, occupational variables were available for all people living in small- and medium-sized municipalities and for one-third of those living in larger municipalities. This resulted in under-representation of people living in larger municipalities in our study. However, we included a representative sample of the Italian population living in large municipalities; hence, the sampling frame is expected to have had a negligible impact (if any) on the MRRs provided in this study.

Further, the multiple testing we made to verify differences in cause-specific mortality across social classes may have yielded some false positive results, i.e. we may have got a significant result simply due to chance (Catelan et al. 2011).

Finally, the possible misclassification or underreporting of causes of death should be considered when evaluating the disparities in mortality from the more detailed causes. However, the archives of mortality provided by the ISTAT, having a national coverage and a standardized coding system, are valid data source for international organizations such as the Statistical Office of the European Union (Eurostat) and the WHO.

In conclusion, there are remarkable disparities across occupation-based social classes in the working Italian population that favour the upper non-manual workers and remarkable sex differences in the pattern of association between occupation-based social class and mortality. Although occupation and education are correlated and frequently interchanged, occupation has an independent effect on mortality once education is taken into account. These data could be useful in planning policies for a more effective health and social security system.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflicts of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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