Socioeconomic inequalities in overall and COVID-19 mortality during the first outbreak peak in Emilia-Romagna Region (Northern Italy)

Disuguaglianze socioeconomiche nella mortalità totale e correlata al COVID-19 durante il primo picco epidemico in regione Emilia-Romagna

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ABSTRACT

OBJECTIVES: to provide a description of inequalities in overall and COVID-19 mortality by ecological socioeconomic measures (ESEMs) during the first outbreak peak (March and April 2020) in Emilia-Romagna Region.

DESIGN: cross-sectional study based on the record linkage of the COVID-19 notification system, the regional population health register and the 2011 census data.

SETTING AND PARTICIPANTS: residents in Emilia-Romagna who were grouped according to three ESEMs calculated at census block level: the index of deprivation, the household crowding, and the percentage of the foreign resident population.

MAIN OUTCOME MEASURES: counts of all deaths and those directly attributable to COVID-19. The association between mortality and ESEMs was assessed through rate differences and mortality rate ratios, estimated through Poisson models.

RESULTS: during the outbreak peak, the nine provinces of the Emilia-Romagna Region were unequally hit by the COVID-19 outbreak, with Piacenza recording the highest COVID-19 absolute death toll and Ferrara the lowest. The overall and COVID-19 mortality burden was unequal also in terms of ecological socioeconomic measures. Percentage differences in the age-standardised mortality rates between the least and the most disadvantaged census blocks were greater for COVID-19 mortality than for overall mortality, suggesting that the Coronavirus outbreak has had a stronger impact on the most socioeconomically deprived areas. Although clear gradients were not always present, people living in the most disadvantaged census blocks experienced the highest absolute and relative risk of dying. Rate differences were larger among men, but mortality rate ratios were not always greater among men than women, especially for the COVID-19 mortality.

CONCLUSIONS: these descriptive yet informative results are relevant to document inequalities and inform regional public health policies and interventions in case of new COVID-19 surges.

Keywords: COVID-19, mortality, socioeconomic attributes, inequalities

WHAT IS ALREADY KNOWN

- **The outbreak caused by the novel Coronavirus SARS-CoV-2 has spread globally, with Italy reporting 241,819 cases and 34,869 deaths as of 7 July 2020.**
- **In Emilia-Romagna Region 3,904 deaths in individuals positive to the SARS-CoV-2 occurred between February 23 and May 15 2020.**
- **Scientific and media reports, both in the USA and Europe, have started to document the disproportionate burden of disease and mortality directly attributable to SARS-CoV-2 infection among socioeconomically disadvantaged population groups.**

WHAT THIS STUDY ADDS

- **This study provides the first comprehensive account of the distribution of the burden of overall and COVID-19 mortality by socioeconomic characteristics in Emilia-Romagna Region.**
- **People living in the most disadvantaged census blocks of the Emilia-Romagna Region showed an increased risk of overall and COVID-19 death during the first outbreak peak (March and April 2020).**
- **Absolute differences were larger among men, but relative ones did not show the same pattern, especially for the COVID-19 mortality.**

RIASSUNTO

OBIETTIVI: fornire una descrizione delle disuguaglianze socioeconomiche nella mortalità totale e in quella correlata al COVID-19 durante il primo picco dell'epidemia (marzo e aprile 2020) nella regione Emilia-Romagna tramite l'utilizzo di indicatori socioeconomici misurati a livello di sezione di censimento.

DISEGNO: studio trasversale basato sul *record-linkage* del sistema di notifica COVID-19, l'anagrafe regionale degli assistiti e i dati del censimento del 2011.

SETTING E PARTECIPANTI: residenti in Emilia-Romagna raggruppati sulla base di tre indicatori socioeconomici misurati a livello di sezione di censimento: indice di deprivazione, grado di affollamento dell'abitazione, percentuale di popolazione residente straniera.

PRINCIPALI MISURE DI OUTCOME: morti totali e morti direttamente attribuibili a COVID-19. L'associazione tra mortalità e indicatori socioeconomici è stata valutata attraverso differenze tra tassi e rapporti tra tassi di mortalità, stimati attraverso modelli di Poisson.

RISULTATI: durante il picco dell'epidemia, le nove province dell'Emilia-Romagna sono state colpite in modo diseguale dall'epidemia COVID-19: Piacenza ha registrato il più alto numero assoluto di morti COVID-19 mentre Ferrara quello più basso. Il carico di mortalità totale e direttamente correlata a COVID-19 è stato diseguale anche in termini di caratteristiche socioeconomiche. Le differenze percentuali nei tassi di mortalità tra le sezioni di censimento meno svantaggiate e quelle più svantaggiate sono state più intense per la mortalità COVID-19 rispetto a quella totale, suggerendo che l'epidemia di Coronavirus abbia avuto un impatto maggiore

nelle aree più deprivate. Sebbene i gradienti nella mortalità non siano sempre chiaramente apprezzabili, il rischio di morte, sia in termini assoluti sia relativi, è stato costantemente più alto tra i soggetti che vivono nelle sezioni di censimento più svantaggiate. Le differenze tra tassi sono state più importanti tra gli uomini, mentre i rapporti tra i tassi sono stati di entità simile nei due sessi, specialmente per la mortalità COVID-19.

CONCLUSIONI: nonostante la loro natura descrittiva, questi risultati documentano la presenza di disuguaglianze socioeconomiche nella mortalità totale e in quella correlata al COVID-19 e dovrebbero essere presi in considerazione nella formulazione di politiche e interventi di sanità pubblica che si porranno in essere in caso di recrudescenze dell'epidemia da COVID-19.

Parole chiave: COVID-19, mortalità, caratteristiche socioeconomiche, disuguaglianze

INTRODUCTION

Since its first report in December 2019 in China, the outbreak of the Coronavirus disease 2019 (COVID-19), caused by the novel Coronavirus SARS-CoV-2 (Severe acute respiratory syndrome Coronavirus 2), has spread worldwide. As of July 7th 2020, 188 countries have confirmed cases, and Italy ranks eleventh among them with 241,819 cases and 34,869 deaths.[1] According to the latest published data, in Emilia-Romagna Region (Northern Italy) 3,904 deaths in individuals positive to the SARS-CoV-2 occurred between February 23 and May 15 2020.[2] Men, people with advanced age and those with underlying medical conditions might be at higher risk for adverse outcomes from COVID-19.[3,4]

Despite the initial widespread opinion that the virus does not discriminate, the SARS-CoV-2 infection, as many of other infectious diseases,[5,6] is likely to hit more strongly people in socioeconomic disadvantage. National and international scholars have argued that the COVID-19 pandemic may amplify the already marked inequalities that exist in our societies, via both direct and indirect mechanisms.[7-10] On the one hand, socioeconomically vulnerable groups may be more exposed to the risk of infection (e.g., less able to practice the physical distancing) and/or present a greater susceptibility to the complications of the disease because of underlying social, age-related, and clinical vulnerabilities. On the other hand, they may be more sensitive to the sudden reorganisation of the health system that has resulted in a reduction of planned services,[8] including those involving the follow-up of chronic conditions whose burden is socially patterned.[11] Additionally, it has been suggested that the medium and long-term socioeconomic consequences of the partial suspension of productive and economic activities during the lockdown, such as the rising in unemployment and poverty rates, are likely to affect more those in already vulnerable conditions and exacerbate social and health inequalities.[12] However, the evidence on the role of socioeconomic factors, including race and ethnicity, in influencing individuals' exposure to the virus and its adverse consequences is still limited, a factor that may hinder the efforts to control the epidemic.[13] A review of the literature carried out in April 2020 concluded that, from 29 eligible studies that described the characteristics of patients with COVID-19 and their potential risk factors, only one reported the occupational position of patients with mild or severe disease.[14] More recently, scientific and media reports, both in the USA and Europe, have started to document the disproportionate burden of disease and mortality directly attributable to the SARS-CoV-2 infection among socioeconomically disadvantaged population groups, including those with a migratory background or ethnic minorities.[15-19] To our knowledge, public information on the COVID-19 cases or mortality by indicators of socioeconomic position are not currently available in Italy. However, the Italian national statistics institute has recently released a nationwide analysis on socioeconomic inequalities in overall mortality during the first trimester of 2020 that shows an increase in relative differences between the low and high educated during the COVID-19 epidemic.[20]

The paucity of evidence as well as the first documentation of socioeconomic inequalities in the distribution of the COVID-19 burden highlights the importance of collecting and analysing socioeconomic data in order to understand how these factors impact on the risk of getting infected and experiencing adverse outcomes.[8,14]

Socioeconomic indicators are rarely available in or easily linkable to medical records, yet area-based socioeconomic measures, which can be attributed to individuals according to their area of residence, have shown to be valid alternatives to reveal health inequalities and to understand the impact of the neighbourhood context on health.[21,22] Analyses based on ecological sociodemographic attributes can easily be implemented even when indicators of socioeconomic position at individual level are not readily available and can provide a description of social inequalities to contribute informing public health policies and prevention measures in a timely fashion, especially when there is an urgent need to document those disparities as it has been recommended by Chen JT, et al. in the case of the COVID-19 outbreak.[16]

Building on these premises, this work aims at providing a description of socioeconomic inequalities in overall and COVID-19 mortality by census block level socioeconomic attributes during the first outbreak peak (March and April 2020) in Emilia-Romagna Region.

MATERIALS AND METHODS

MORTALITY DATA

Mortality data were collected for March and April 2020, the two months during which the death toll was the highest in Emilia-Romagna according to the regional mortality surveillance data.[2] The count of all deaths among residents was obtained from the regional population health

register (RPHR); it contains demographic information, including the census block (assigned through a geocoding procedure), on all subjects who had at least one contact with the regional health service or are resident in any of the regional municipalities, and virtually covers the entire population resident or present in the region (with the exception, for example, of homeless people without any residential address).[23] The RPHR is fed, among other sources, by the national health insurance card system, which guarantees a timely update of the vital status information. Data on deaths directly attributable to COVID-19 were obtained from the regional COVID-19 notification system, a new database that collects demographic and clinical information on subjects diagnosed with the SARS-CoV-2 infection. This subset of deaths was linked to the RPHR through an anonymous key, which uniquely identifies all individuals within the RPHR and the regional health databases, in order to assign the census block. Counts of total deaths and those due to COVID-19 were subsequently aggregated by census block, sex, and age group.

POPULATION DENOMINATORS AND ECOLOGICAL SOCIOECONOMIC MEASURES

The resident population as of 01.01.2020 was obtained from the RPHR and aggregated by census block, gender, and age group. The socioeconomic attributes, measured at census block level and retrieved from the 2011 census, were:

- the index of deprivation (ID), a summary measure of social and material deprivation based on five census variables (low level of education, unemployment, non-home ownership, single-parent family, and household crowding);[24]
- the household crowding: a component of the ID that measures the number of people per 100 square metres of the house surface and that, beyond being a risk factors for infections' transmission,[25] reflects the material living conditions;
- the percentage of the foreign resident population: a proxy for social and economic disadvantage.

All these ecological measures were grouped into population quintiles of the regional distribution.

DATA MANAGEMENT AND STATISTICAL METHODS

The counts of all deaths and those due to COVID-19 aggregated by census block, gender, and 10-years age group were linked with the population denominators and, subsequently, to the database containing the ecological socioeconomic measures (ESEMs) at census block level. The performance of the linkages was good: only 5% of the total deaths (12,844/13,418) and 7% of those due to COVID-19 (3,301/3,531) were not successfully associated to the population denominators or not geocoded. ESEMs are not available for all census blocks; the number of deceased who were geocoded but not assigned an ESEM are reported in table 1 and table 2: the proportion of deaths with missing ESEMs was always < 1%. Mortality rates per 100,000 population were age-adjusted using the 2011 Italian population as standard and 95% confidence intervals were calculated using standard methods.[26] Based on an analysis proposed by the Office for national statistics,[17] we calculated the percentage differences between the age-standardised overall and COVID-19 mortality rates of the most and the least disadvantage census blocks by ESEMs. To evaluate inequalities on both the absolute and the relative scale, we estimated rate differences (RDs) and mortality rate ratios (MRRs), through Poisson models, using the least disadvantaged quintiles as reference. A likelihood ratio test (LRT) was applied in order to assess the presence of a linear trend in the MRRs, setting its alpha value at 0.05.

RESULTS

Between March 1st and April 30th 2020, 13,418 deaths occurred in Emilia-Romagna (49.8% in men); of these, 3,531 were recorded in subjects with the SARS-CoV-2 infection (26.3% of the total deaths, 59% in men). The highest number of total deaths was observed in the province of Bologna (2,548 deaths, 20.8% COVID-19), the lowest in the province of Ferrara (860 deaths, 13.9% COVID-19). The province with the highest proportion of COVID-19 deaths was Piacenza with 863 deaths, representing 50.2% of the total; the one with the lowest was Ferrara with 63 deaths (7.1% of the total) (figure 1). Age-standardised COVID-19 mortality rates were highest in the province of Piacenza (342.94 per 100,000 population among men and 128.05 per 100,000 among women), and lowest in the province of Ravenna (20.77 per 100,000 population among men and 7.86 per 100,000 among women).
Both overall and COVID-19 age-standardised mortality

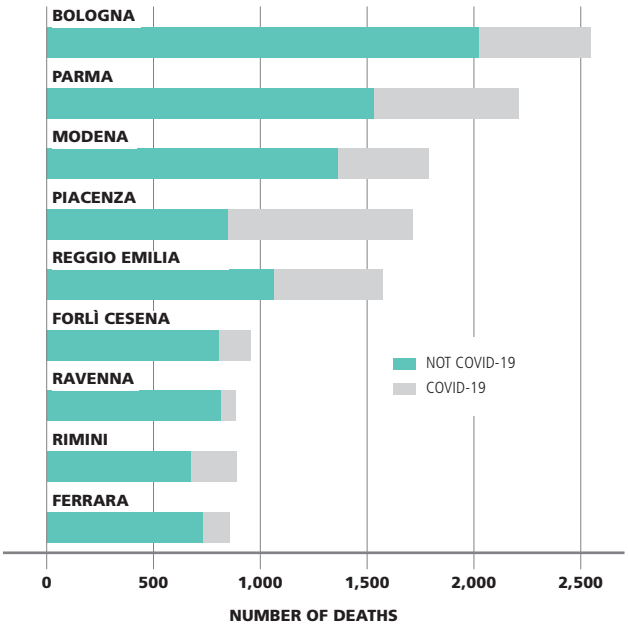

Figure 1. Number of overall and COVID-19 deaths occurring between 01.03.2020 and 30.04.2020 by province, Emilia-Romagna region (Northern Italy).
Figura 1. Numero di decessi totali e attribuibili a COVID-19 tra il 01.03.2020 e il 30.04.2020 per provincia, regione Emilia-Romagna.

	MALES									FEMALES								
	NUMBER OF DEATHS	POPULATION	AGE-STANDARDISED MORTALITY RATE (PER 100,000)	95%CI	RATE DIFFERENCES (PER 100,000)	95%CI	MORTALITY RATE RATIO	95%CI	P-VALUE LRT	NUMBER OF DEATHS	POPULATION	AGE-STANDARDISED MORTALITY RATE (PER 100,000)	95%CI	RATE DIFFERENCES (PER 100,000)	95%CI	MORTALITY RATE RATIO	95%CI	P-VALUE LRT
INDEX OF DEPRIVATION (QUITILES)																		
1	1,392	435,869	267.71	(253.75;281.66)			1		<0.001	1,278	455,865	168.04	(158.61;177.48)			1		<0.001
2	1,235	416,381	273.33	(258.22;288.44)	5.62	(-15.14;26.38)	1.02	(0.95;1.10)		1,217	441,155	172.01	(162.13;181.90)	14.48	(0.34;28.62)	1.04	(0.97;1.13)	
3	1,161	418,514	271.04	(255.59;286.48)	3.33	(-17.69;24.35)	1.01	(0.94;1.10)		1,193	442,043	177.77	(167.45;188.08)	21.66	(7.34;35.97)	1.07	(0.99;1.15)	
4	1,248	425,411	302.70	(286.07;319.33)	34.99	(13.06;56.92)	1.13	(1.05;1.22)		1,264	446,934	189.75	(179.02;200.47)	18.63	(4.45;32.82)	1.11	(1.03;1.20)	
5	1,302	459,562	329.30	(311.58;347.02)	61.60	(38.79;84.40)	1.23	(1.14;1.33)		1,468	467,976	218.87	(207.31;230.43)	55.69	(40.86;70.53)	1.12	(1.04;1.21)	
MISSING	36	8,971								50	8,683							
HOUSEHOLD CROWDING (QUINTILES)																		
1	1,453	449,939	270.80	(256.98 284.62)			1		<0.001	1,406	473,600	169.82	(160.64;179.00)			1		0.001
2	1,299	423,335	281.10	(265.96;296.25)	10.30	(-10.40;31.00)	1.04	(0.96;1.12)		1,338	445,675	183.55	(173.47;193.64)	13.73	(-0.01;27.47)	1.09	(1.01;1.17)	
3	1,246	423,879	286.68	(270.91;302.44)	15.88	(-5.29;37.05)	1.06	(0.98;1.14)		1,251	445,806	182.09	(171.76;192.43)	12.27	(-1.65;26.20)	1.08	(1.00;1.16)	
4	1,168	423,788	285.01	(268.82;301.19)	14.20	(-7.30;35.70)	1.05	(0.98;1.14)		1,172	443,905	182.50	(171.84;193.15)	12.68	(-1.49;26.85)	1.08	(1.00;1.16)	
5	1,181	437,248	319.75	(301.67;337.83)	48.94	(25.94;71.95)	1.18	(1.09;1.28)		1,268	447,439	212.65	(200.68;224.63)	42.83	(27.63;58.04)	1.25	(1.16;1.35)	
MISSING	27	6,519								35	6,231							
PROPORTION OF FOREIGN RESIDENT POPULATION (QUINTILES)																		
1	1,284	437,350	258.82	(244.79;272.86)			1		<0.001	1,254	455,679	174.31	(164.47;184.14)			1		0.011
2	1,223	413,996	272.72	(257.57;287.86)	13.89	(-6.96;34.74)	1.05	(0.97;1.14)		1,264	441,535	185.99	(175.58;196.40)	11.69	(-2.74;26.12)	1.07	(0.99;1.16)	
3	1,228	413,361	278.02	(262.62;293.43)	19.20	(-1.84;40.25)	1.08	(0.99;1.16)		1,267	439,909	181.69	(171.42;191.95)	7.38	(-6.94;21.70)	1.05	(0.97;1.13)	
4	1,284	427,116	297.57	(281.44;313.70)	38.75	(17.15;60.34)	1.15	(1.07;1.24)		1,354	450,857	188.48	(178.12;198.84)	14.17	(-0.22;28.57)	1.09	(1.01;1.18)	
5	1,346	468,692	339.41	(321.43;357.39)	80.60	(57.54;103.66)	1.31	(1.21;1.41)		1,324	470,824	196.16	(185.18;207.14)	21.85	(7.01;36.70)	1.11	(1.02;1.20)	
MISSING	9	4,193								7	3,852							

Table 1. Number of overall deaths, population, age-standardised mortality rates, mortality rate differences and ratios (with their relative 95%CI), and p-values from the likelihood ratio test (LRT) for the mortality rate ratios by census block socioeconomic attributes and sex, Emilia-Romagna Region, 01.03.2020-30.04.2020.

Tabella 1. Numero di morti totali, popolazione, tassi standardizzati per età, differenze e rapporti tra tassi (con i relativi IC95%) e p-value del test di verosimiglianza (LRT) per i rapporti tra tassi per indicatori socioeconomici misurati a livello di sezione di censimento e genere, regione Emilia-Romagna, 01.03.2020-30.04.2020.

	MALES									FEMALES								
	NUMBER OF DEATHS	POPULATION	AGE-STANDARDISED MORTALITY RATE (PER 100,000)	95%CI	RATE DIFFERENCES (PER 100,000)	95%CI	MORTALITY RATE RATIO	95%CI	P-VALUE LRT	NUMBER OF DEATHS	POPULATION	AGE-STANDARDISED MORTALITY RATE (PER 100,000)	95%CI	RATE DIFFERENCES (PER 100,000)	95%CI	MORTALITY RATE RATIO	95%CI	P-VALUE LRT
INDEX OF DEPRIVATION (QUINTILES)																		
1	402	435,869	77.55	(69.98;85.13)			1		<0.001	264	455,865	35.45	(31.06;39.85)			1		<0.001
2	383	416,381	84.85	(76.37;93.33)	7.30	(-4.10;18.69)	1.10	(0.95;1.26)		235	441,155	34.80	(30.24;39.36)	-0.65	(-7.00;5.69)	0.97	(0.81;1.16)	
3	339	418,514	79.35	(70.92;87.78)	1.79	(-9.56;13.15)	1.03	(0.89;1.18)		224	442,043	34.25	(29.65;38.86)	-1.20	(-7.58;5.17)	0.96	(0.80;1.15)	
4	385	425,411	93.74	(84.40;103.08)	16.19	(4.13;28.24)	1.21	(1.05;1.39)		272	446,934	41.64	(36.54;46.74)	6.18	(-0.56;12.93)	1.18	(1.00;1.40)	
5	422	459,562	107.17	(96.96;117.39)	29.62	(16.87;42.37)	1.39	(1.21;1.59)		362	467,976	55.43	(49.50;61.37)	19.98	(12.58;27.38)	1.55	(1.33;1.82)	
MISSING	10	8,971								3	8,683							
HOUSEHOLD CROWDING (QUINTILES)																		
1	429	449,939	80.21	(72.63;87.79)			1		0.015	275	473,600	35.06	(30.77;39.35)			1		0.821
2	383	423,335	83.26	(74.94;91.59)	3.05	(-8.23;14.34)	1.03	(0.90;1.19)		247	445,675	34.97	(30.48;39.45)	-0.09	(-6.31;6.12)	1.02	(0.86;1.22)	
3	386	423,879	88.91	(80.06;97.76)	8.70	(-2.98;20.38)	1.11	(0.97;1.27)		287	445,806	43.05	(37.93;48.17)	7.99	(1.30;14.69)	1.26	(1.07;1.49)	
4	359	423,788	87.90	(78.82;96.97)	7.69	(-4.17;19.54)	1.09	(0.95;1.26)		244	443,905	39.10	(34.07;44.12)	4.04	(-2.58;10.66)	1.15	(0.96;1.36)	
5	377	437,248	102.26	(91.94;112.58)	22.0	(9.2;34.9)	1.27	(1.11;1.46)		306	447,439	51.02	(45.13;56.90)	15.96	(8.66;23.25)	1.54	(1.31;1.82)	
MISSING	7	6,519								1	6,231							
PROPORTION OF FOREIGN RESIDENT POPULATION (QUINTILES)																		
1	358	437,350	71.83	(64.41;79.26)			1		<0.001	260	455,679	36.35	(31.84;40.86)			1		0.113
2	335	413,996	74.52	(66.55;82.49)	2.69	(-8.23;13.60)	1.04	(0.89;1.20)		256	441,535	38.83	(33.98;43.68)	2.48	(-4.16;9.11)	1.05	(0.88;1.24)	
3	390	413,361	88.45	(79.69;97.20)	16.61	(5.10;28.12)	1.23	(1.07;1.42)		274	439,909	40.11	(35.21;45.01)	3.76	(-2.91;10.43)	1.10	(0.93;1.30)	
4	411	427,116	95.64	(86.41;104.87)	23.80	(11.93;35.68)	1.34	(1.16;1.54)		276	450,857	39.65	(34.80;44.50)	3.30	(-3.33;9.94)	1.08	(0.91;1.28)	
5	443	468,692	113.22	(102.68;123.76)	41.39	(28.46;54.32)	1.57	(1.37;1.80)		294	470,824	45.79	(40.32;51.25)	9.44	(2.34;16.53)	1.20	(1.02;1.42)	
MISSING	4	4,193								0	3,852							

Table 2. Number of COVID-19 deaths, population, age-standardised mortality rates, mortality rate differences and ratios (with their relative 95% confidence intervals - CI), and p-values from the likelihood ratio test (LRT) for the mortality rate ratios by census block socioeconomic attributes and sex, Emilia-Romagna Region, 01.03.2020-30.04.2020.

Tabella 2. Numero di morti direttamente attribuibili a COVID-19, popolazione, tassi standardizzati per età, differenze e rapporti tra tassi (con i relativi intervalli di confidenza al 95%) e p-value del test di verosimiglianza (LRT) per i rapporti tra tassi per indicatori socioeconomici misurati a livello di sezione di censimento e sesso, regione Emilia-Romagna, 01.03.2020-30.04.2020.

rates (ASMRs) were higher among men than women and generally greater among those living in the most disadvantaged versus most advantaged census blocks, irrespective of the socioeconomic attribute used (table 1 and 2). Age had an important effect resulting in a noticeable changes between crude (not calculated) and age-adjusted rates.

ASMRs for overall mortality (most *vs* least disadvantaged) were as follows: for the index of deprivation 329.30 *vs* 267.71 per 100,000 population among men, 218.87 *vs* 168.04 per 100,000 among women; for household crowding 319.75 *vs* 270.80 per 100,000 among men, 212.65 *vs* 169.82 per 100,000 among women; for the percentage of the foreign resident population 339.41 *vs* 258.82 per 100,000 among men, 196.16 *vs* 174.31 per 100,000 among women.

ASMRs for COVID-19 mortality (most *vs* least disadvantaged) were as follows: for the deprivation index 107.17 *vs* 77.55 per 100,000 population among men, 55.43 *vs* 35.45 per 100,000 among women; for household crowding 102.26 *vs* 80.21 per 100,000 among men, 51.02 *vs* 35.06 per 100,000 among women; for the percentage of the foreign resident population 113.22 *vs* 71.83 per 100,000 among men, 45.79 *vs* 36.35 per 100,000 among women.

Figure 2 shows the ASMRs as a percentage difference from the least disadvantaged quintile for total and COVID-19 deaths for each of the socioeconomic attribute. Although there was not a clear gradient for all of them, the most disadvantaged census blocks reported consistently higher percentage increases in the ASMRs for both overall and COVID-19 mortality as well as consistently greater percentage increases in the ASMRs for COVID-19 deaths than those for total deaths.

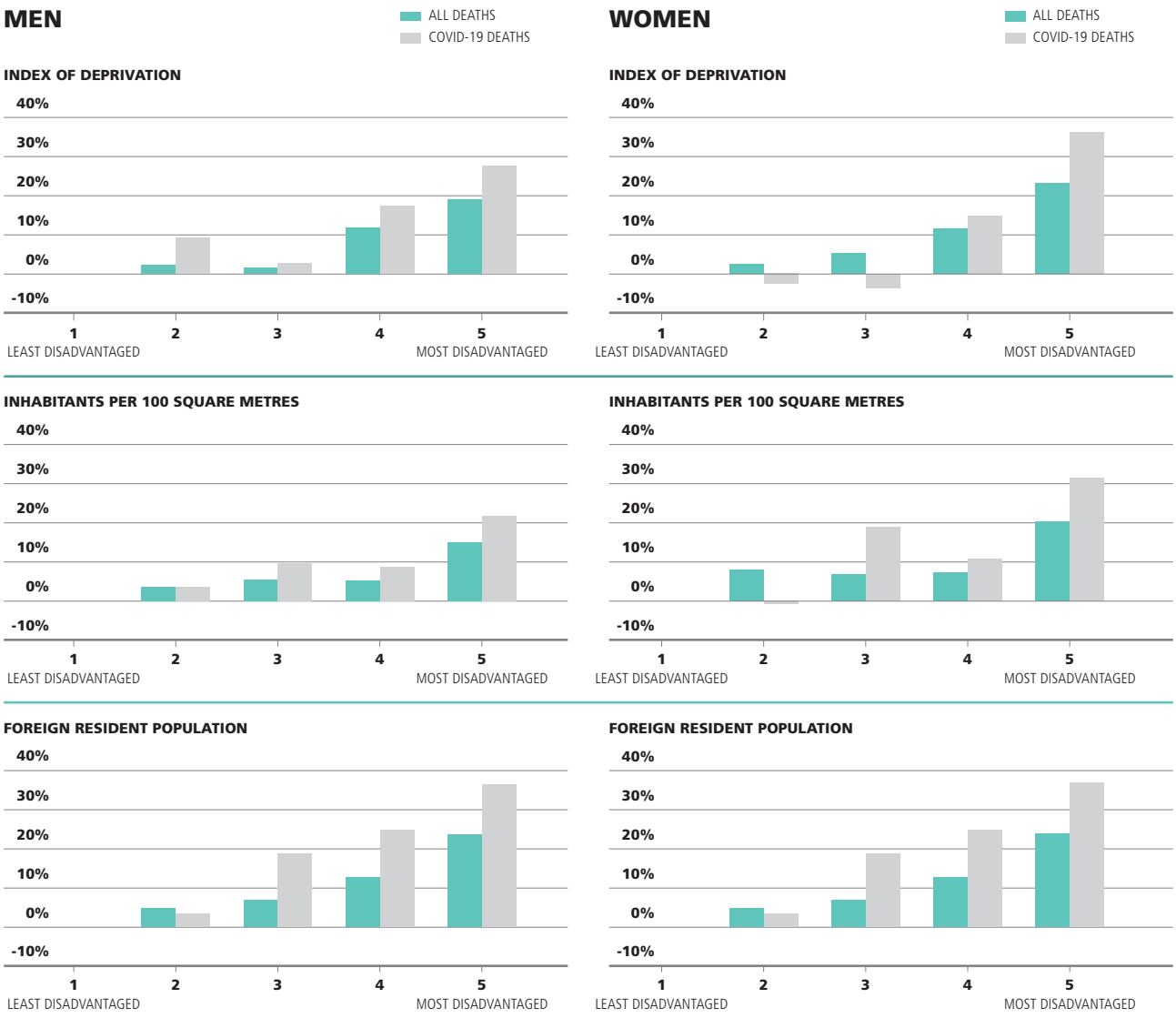

Figure 2. Percentage differences between the age-standardised overall and COVID-19 mortality rates of the most and the less disadvantage census blocks by socioeconomic attributes, 01.03.2020-30.04.2020, Emilia-Romagna Region (Northern Italy).
Figura 2. Differenza percentuale tra i tassi standardizzati per età delle aree più svantaggiate e quelli delle aree meno svantaggiate per indicatori socioeconomici, mortalità totale e direttamente attribuibile a COVID-19, 01.03.2020-30.04.2020, regione Emilia-Romagna.

The two measures of absolute and relative differences described further socioeconomic disparities in the risk of total and COVID-19 mortality (table 1 and 2). For both total and COVID-19 mortality, the RDs of subjects living in the most versus the least advantaged areas were the largest for the index of deprivation among women (overall mortality: 55.69 per 100,000 population; COVID-19 mortality: 19.98 per 100,000) and for the proportion of foreign resident population among men (overall mortality: 80.60 per 100,000 population; COVID-19 mortality: 41.39 per 100,000). RDs were generally greater among men than women. These figures represent the differences in the mortality rates that would be observed in the Italian standard population. Relative differences tended to be relatively larger for the COVID-19 mortality than for overall mortality. Socioeconomic gradients were not always monotonic, but the risk of death was consistently higher among the most compared to the least disadvantaged. Moreover, the LRTs revealed that a linear trend was present for most of the relationships tested (p-values were ≤0.001 for the majority of the associations with the exception of those between COVID-19 mortality and household crowding and percentage of foreign resident population among women). A clear monotonic gradient was observed for overall and COVID-19 mortality by the percentage of foreign resident population among men. Of note, MRRs were not always greater among men than women, especially for the COVID-19 mortality.

DISCUSSION

SUMMARY OF RESULTS

This is the first comprehensive account of the distribution of the burden of overall and COVID-19 mortality during the first outbreak peak by socioeconomic characteristics in Emilia-Romagna Region. The nine provinces were unequally hit by the COVID-19 outbreak, with Piacenza recording the highest COVID-19 absolute death toll and Ferrara the lowest. The overall and COVID-19 mortality risk was unequal also in terms of ecological socioeconomic measures. Percentage differences in the age-standardised mortality rates between the least and the most disadvantaged census blocks were greater for COVID-19 mortality than for overall mortality, suggesting that the Coronavirus outbreak has had a stronger impact on the most socioeconomically deprived areas. Although clear gradients were not always present, people living in the most disadvantaged census blocks experienced the highest absolute and relative risk of dying. Rate differences were larger among men, but mortality rate ratios did not show the same pattern, especially for the COVID-19 mortality.

INTERPRETATION

Inequalities in mortality from all causes and major causes of death at the population level are widely reported nationally and internationally.[27,28] Therefore it comes as no surprise to find unpalatable socioeconomic differences in overall mortality, in fact they have already been documented in Emilia-Romagna.[29-31] However, on the basis of the widespread perception of a «democratic virus», which was echoed by the message of the Director-General of the World Health Organisation that «COVID-19 does not discriminate between rich nations and poor, […] nationalities, ethnicities or ideologies»,[32] one would expect COVID-19 risk and outcomes not to be socially patterned. Unfortunately, the reports that so far have focused on the unequal burden of disease and mortality in relation to COVID-19 have consistently shown that the most deprived strata of the population are experiencing the greatest risks of infection, hospitalisation and adverse outcomes.[15-19] Increased educational inequalities during the first trimester of 2020 have been reported also in Italy.[20]

The results of our study support the hypothesis that the COVID-19 mortality burden is heavier on the most disadvantaged areas of the Emilia-Romagna Region, which we have defined on the basis of three ecological indicators that reflect the material conditions and the socio-cultural environment in which people live. Moreover, we also showed that the relative differences between the least and the most disadvantaged areas were greater for COVID-19 mortality than for overall mortality, suggesting that COVID-19 related disparities may go above and beyond what we would expect for total mortality. It has been argued that the mechanisms underlying health inequalities during the COVID-19 outbreak are multifaceted.[8,33] People living the most socially and economically deprived neighbourhoods, which may overlap those where migrants or ethnic minorities live, may be more exposed to the risk of infection from SARS-CoV-2 and to its adverse outcomes. On the one hand, they are more likely to experience poor housing conditions and overcrowding, which is a well-known risk factor for respiratory and gastrointestinal infections,[34] and that may prevent individuals from distancing and/or self-isolating appropriately. On the other hand, those people are more often employed in «essential jobs» that entail a greater interaction with others and cannot be done remotely (i.e. cleaners, caregivers, sale assistants) and may make them less able to practice an effective physical distancing.[16] In addition, the most deprived population groups have a higher prevalence of chronic conditions and unhealthy behaviours,[35] including smoking,[36] and may face greater barriers in timely accessing the health system,[37] all conditions that increase their frailty and then their vulnerability to the adverse outcomes of COVID-19.[3] In our study, we relied only on mortality data and therefore we are unable to tell whether the observed disparities are attributable to differences in exposure, incidence, and susceptibility among the exposed or to the severity of the clinical conditions which are linked to both the presence of comorbidities and/or obstacles to health care access. Future analyses may help to shed light on these complex pathways.

Age-adjusted mortality rate differences were always larger for men, but this was not the case for relative differences, notably for the COVID-19 mortality, where men and women showed comparable increases in the mortality risk. Similar findings have been reported by Krieger N, et al. for the excess mortality in Massachusetts, USA, during the first two weeks of April 2020.[38] COVID-19 mortality gender differential have been shown to vary also by age groups.[39] These results highlight the importance of looking at both absolute and relative differences, collecting gender and age disaggregated data and fostering an informed debate on the association between the social aspects of gender and/or the gender-linked biology and the exposure and susceptibility to COVID-19.[38]

STRENGTHS AND LIMITATIONS

In this study we looked at deaths occurred in March and April, the two months during which the death toll was highest in Emilia-Romagna.[2] Unlikely the number of confirmed cases, which depends on the testing strategies and coverage, the number of deaths remains a strong indicator of the health status of the population. Still, a certain under-reporting of deaths due to COVID-19 is possible mainly because people may have died at home or in community settings (i.e., nursing facilities) before being tested for SARS-CoV-2. This may have been an issue particularly in the first weeks of the spring outbreak when the demand for testing and health care assistance outnumbered the capacity of the health system. Disparities in the COVID-19 mortality may be underestimated if living in disadvantaged areas was associated with a lower testing rates and a lower access to the health system. Evidence on the unequal access to testing by socioeconomic conditions is currently unavailable but this possibility cannot be completely ruled out, as informal communications with health care professionals locally involved in the emergency management seem to suggest that this may have happened in some instances.

Although the linkage processes were highly successful, not all deceased were assigned a census block and therefore they were not included in the analyses. If the probability of linkage depended on the area of residence, we could have either underestimated or overestimated the magnitude of disparities by ecological socioeconomic measures.

It has been reported that area level socioeconomic measures tend to reveal smaller associations with health outcomes than individual indicators of socioeconomic position.[40] This underestimation of the association arises from the misclassification of individual socioeconomic conditions when measured by the characteristics of the residential area; the larger the area the greater the misclassification.[41] In this work, the analyses were carried out at census block level that on average contains 120 individuals and is the smallest area for which aggregated information on socioeconomic attributes are available: this should minimise the misclassification embedded in this type of measure. This limitation may be overcome by using individual indicators of socioeconomic position, which are usually retrieved through the linkage of multiple health and statistical datasets. The Emilia-Romagna Region has recently set up a regional longitudinal study (Emilia-Romagna longitudinal study), a monitoring system based on the integration of the RPHR, the 2011 census and the electronic health records, including the mortality register, which gathers socioeconomic and clinical information at individual level for the resident population.[31] The analysis of these data, along with the causes of death that will become available over the next few months, will allow a deeper and finer investigation of the direct and indirect impact of the COVID-19 outbreak on socioeconomic inequalities in health at regional level.

Despite the above-mentioned limitations, our results are still relevant to help identifying the population groups that have been hardest hit by the recent COVID-19 outbreak and that are likely to be hit again in case of new COVID-19 surges. The scientific community has argued that the identification of high-risk communities in the pandemic context is not only a key element to inform an effective health and economic resources allocation in times of human resources and financial constraints but also a fundamental step to call on governments for the implementation of health care, social, economic, and cultural measures to promote people's right to health and reduce health inequalities, and to hold them accountable for their policy response.[8,10,16]

CONCLUSIONS

People living in the most disadvantaged census block of the Emilia-Romagna showed an increased risk of overall and COVID-19 death during the first epidemic peak. Although further research is needed to study the association between individual indicators of socioeconomic position and overall and cause-specific mortality, these descriptive yet informative results are relevant to document inequalities and to inform regional public health policies and interventions in case of new COVID-19 surges.

Conflicts of interest declared: none.

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