

Area-level indicators of income and total mortality during the COVID-19 pandemic

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Background: There is mounting evidence that socioeconomic inequalities in mortality have widened during the COVID-19 pandemic. This study aimed at evaluating the relationship between area-level indicators of income and total mortality during the first phase of COVID-19 pandemic in the most hit Italian region. **Methods:** We conducted an ecological study based on the number of deaths registered in the municipalities of the Lombardy region (Italy) between January 2019 and June 2020. Municipalities were grouped according to quintiles of average income and pension of their resident population. Monthly age-standardized mortality ratios (MRs) between the poorest and the richest municipalities and the corresponding 95% CI were computed to evaluate whether the pre-existing socioeconomic inequalities widened during the pandemic. **Results:** Over the study period, 175 853 deaths were registered. During the pre-pandemic period (January 2019 to February 2020) the MR between the poorest and the richest municipalities ranged between 1.12 (95% CI: 1.00–1.25) and 1.33 (95% CI: 1.20–1.47). In March 2020, when the pandemic began to rapidly spread in the region, it raised up to 1.61 (95% CI: 1.51–1.72) and decreased thereafter, reaching the pre-pandemic values in April 2020. Similar results were observed in the analysis of the mortality at ages 65 and over in municipalities grouped according to average pension, where the MR increased up to 1.82 (95% CI: 1.70–1.94) in March 2020. **Conclusions:** The socioeconomic inequalities in mortality widened in Lombardy, the Italian region most severely hit during the first phase of the COVID-19 pandemic.

Introduction

Socioeconomic inequality in health is a long-lasting and still unsolved problem. Even in modern and high-income societies, higher mortality rates have been consistently observed in poor areas with low levels of education and high unemployment rates.^{1–3}

At the end of February 2020, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection spread in Northern Italy, causing an excess total mortality in Italy of more than 45 000 deaths by the end of April, though <28 000 deaths were officially registered as coronavirus disease 2019 (COVID-19) deaths.⁴ Later, the lockdown measures to contain the infection, plus the implementation of a surveillance system, and a reorganization of hospital care, particularly emergency and intensive care units, succeeded in preventing further excess in total mortality in the following months, although after the summer season with the reopening of the economic activities and loosening of distancing measures the number of new infections started to rise again.

Lombardy, the most populous and richest region of the country, was the region most severely hit during the hardest phase of the pandemic with more than 55% of the excess deaths occurring in that region.

There is mounting evidence that pre-existing socioeconomic inequalities in mortality have widened during the pandemic and the research community called for more data to monitor this phenomenon.^{5–7} Thus, in this study, we aimed at evaluating the relationship between area-level indicator of income and total mortality in Lombardy.

Methods

We conducted an ecological study based on the number of deaths registered in the municipalities of Lombardy region between January

2019 and June 2020 and two area-level indicators of income, i.e. the average income and pension of the resident population in each municipality.

Total deaths in each municipality were downloaded from provisional daily mortality data published by the National Institute of Statistics that cover 1469 out of 1506 of the municipalities of the region (98.9% of the population).⁸

For each municipality, we computed the average income of the resident population by dividing the municipal taxable income by the total taxpayers. This information was obtained from the Tax Register for the calendar year 2018 of the Ministry of Economy and Finance.⁹ The average pension was obtained from the same database by dividing the total amount of retirement income by the number of retirees in each municipality. Municipalities were then grouped according to quintiles of average income and pension distribution.

For each group of municipalities, defined by quintiles of average income and pension, we computed the age-specific mortality rate from the number of deaths registered in each month and the person-days at risk over the same month. Then age-standardized death rates (SDRs) and the corresponding standard errors were computed by month using the direct method and the population of the whole Lombardy region on 1 January 2020 as a standard. The SDR was computed for all ages combined, in the analysis by income distribution, and for the age group 65 and over in the analysis by pension distribution.

To quantify the excess mortality among the poorest areas, we also computed the mortality ratio (MR) between the SDR estimated for the number of municipalities with average income or pension below the lowest quintile and those with values above the highest quintile. The 95% CI of the MR was calculated using the binomial approximation.¹⁰

Heterogeneity of the SMR across periods was tested using a chi-squared test.¹¹ The MR observed in March 2020 (when total

mortality peaked) was compared with the MR observed in the previous (January 2019 to February 2020) and in the subsequent (April–June 2020) period. To take into account multiple comparisons, the level of significance was set at 0.025, i.e. the canonical threshold of 0.05 was divided by the number of tests performed ($n = 2$).

Results

Over the observation period, 175 853 deaths were registered, 90% of them in the age group ≥ 65 . The monthly number of deaths ranged between 7253 in September 2019 and 25 227 in March 2020. This figure was remarkably higher than that observed in the same month of the previous year (7861 deaths [Supplementary table S1](#)).

Most deaths occurred in the municipalities with the highest average income (85 301, 48.5% of the total deaths), which were also the most populous, whereas 9567 deaths (5.4% of the total deaths) were registered in the municipalities with average incomes below the lowest quintile. A similar distribution was found when considering the deaths occurred at ages 65 and over in municipalities grouped according to the average pension of their residents.

[Table 1](#) gives the SDRs at all ages and their corresponding standard errors in the municipalities classified according to quintiles of average income distribution of the resident population between January 2019 and June 2020. SDRs at ages 65 and over observed in municipalities classified according to average pension distribution are shown in [table 2](#).

Before March 2020, the SDR at all ages ranged between 2.7 and 4.1 deaths per 100 000 person-days in the municipality with average incomes below the lowest quintile and between 2.4 and 3.2 in those with average incomes above the highest quintile. SDRs at ages 65 and over ranged between 9.9 and 15 deaths in municipalities with average pensions below the lowest quintile and 9.2 and 12.9 deaths in those with average pensions above the highest quintile.

In March 2020, the SDRs peaked in all municipalities and decreased thereafter ([figure 1](#)). However, it was consistently lower in the municipalities with the highest values of income and pension, both in the pre-pandemic period and in the months when the region was hit by the pandemic. In March 2020, the SDRs at all ages reached 10.1 deaths per 100 000 person-days in the poorest municipalities and 6.3 in the wealthiest ones; in March 2019 they were 3.5 and 2.8, respectively. Corresponding figures at ages ≥ 65 : 46.1 and

25.3 in March 2020 and 13.4 and 10.9 deaths per 100 000 person-days in March 2019, in the poorest and in the wealthiest municipalities, respectively. Of note, in March 2020 the municipalities in the lower two-fifths of the income and pension distribution showed the highest SDRs.

[Figure 2](#) shows the MR between municipalities with average incomes or pensions below the lowest and above the highest quintile. During the pre-pandemic period, the MR ranged between 1.12 (95% CI: 1.0–1.25) and 1.33 (95% CI: 1.20–1.47), whereas in March 2020 it raised to 1.61 (95% CI: 1.51–1.72) and decreased thereafter, reaching the pre-pandemic values in April 2020. The increase in the MR was even more remarkable when we considered the mortality at ages 65 and over by average pension. In that case, the MR ranged between 1.07 (95% CI: 0.97–1.17) and 1.24 (95% CI: 1.12–1.38) in the pre-pandemic period and surged up to 1.82 (95% CI: 1.70–1.94) in March 2020. Again, the MR returned to the values observed in the pre-pandemic period in April 2020. The heterogeneity test showed significant differences in the MRs observed in March 2020 and those observed in the previous or subsequent periods ($P < 0.001$ for all tests).

Discussion

In March 2020, the hardest month of the first COVID-19 pandemic wave, the poorest areas in the Lombardy region experienced a substantially higher increase in total mortality.

Our results are in agreement with a recent study¹² conducted in Massachusetts (USA) where total mortality was evaluated between January 2019 and May 2020 according to ZIP code areas that were grouped on the basis of the percentage of people living below the poverty line. In that state, total mortality peaked at mid-April, resulting in an increase in total mortality 2.2 times in the lowest poverty areas and 2.7 times in the highest ones, as compared with those observed in the same period of the previous quinquennium. They also found similar patterns for household crowding and percentage of population of colour in the ZIP area.

Different mechanisms have likely contributed to produce the observed differences. First, COVID-19 is a curable disease if appropriately treated but the most disadvantaged section of the population had probably less access to adequate care. Second, at the beginning of March 2020, the Italian Government implemented a series of measures to control the spread of the infection, including

Table 1 Age-SDR per 100 000 person-days () in the municipalities of the Lombardy region grouped according to quintiles of average income of the resident population

| Month | Groups of municipalities defined by quintiles of average income | | | | |
|----------------|---|--------------------|--------------------|--------------------|---------------------|
| | 1 (<€18 820) | 2 (€18 820–20 429) | 3 (€20 430–21 810) | 4 (€21 811–23 436) | 5 (\geq €23 437) |
| January 2019 | 3.54 (0.16) | 3.82 (0.12) | 3.57 (0.09) | 3.36 (0.08) | 3.14 (0.04) |
| February 2019 | 4.08 (0.18) | 3.77 (0.13) | 3.66 (0.09) | 3.62 (0.08) | 3.18 (0.05) |
| March 2019 | 3.54 (0.16) | 3.22 (0.11) | 3.07 (0.08) | 3.02 (0.07) | 2.76 (0.04) |
| April 2019 | 3.03 (0.15) | 2.77 (0.11) | 2.73 (0.08) | 2.75 (0.07) | 2.59 (0.04) |
| May 2019 | 2.98 (0.14) | 2.81 (0.11) | 2.69 (0.08) | 2.64 (0.07) | 2.48 (0.04) |
| June 2019 | 3.02 (0.15) | 2.93 (0.11) | 2.77 (0.08) | 2.94 (0.07) | 2.62 (0.04) |
| July 2019 | 2.86 (0.14) | 2.72 (0.10) | 2.79 (0.08) | 2.82 (0.07) | 2.50 (0.04) |
| August 2019 | 2.75 (0.14) | 2.77 (0.11) | 2.57 (0.07) | 2.50 (0.07) | 2.45 (0.04) |
| September 2019 | 2.74 (0.14) | 2.63 (0.10) | 2.57 (0.07) | 2.57 (0.07) | 2.36 (0.04) |
| October 2019 | 3.22 (0.15) | 2.73 (0.10) | 2.84 (0.08) | 2.80 (0.07) | 2.55 (0.04) |
| November 2019 | 3.14 (0.15) | 3.10 (0.11) | 2.81 (0.08) | 2.65 (0.07) | 2.71 (0.04) |
| December 2019 | 3.40 (0.15) | 3.07 (0.11) | 3.08 (0.08) | 2.95 (0.07) | 2.73 (0.04) |
| January 2020 | 3.43 (0.15) | 3.21 (0.11) | 3.25 (0.08) | 3.05 (0.07) | 2.83 (0.04) |
| February 2020 | 3.79 (0.17) | 3.16 (0.11) | 3.28 (0.08) | 3.06 (0.07) | 2.85 (0.04) |
| March 2020 | 10.10 (0.26) | 12.53 (0.22) | 10.35 (0.14) | 9.01 (0.12) | 6.28 (0.06) |
| April 2020 | 6.51 (0.21) | 6.30 (0.16) | 6.23 (0.11) | 5.62 (0.10) | 5.17 (0.06) |
| May 2020 | 3.43 (0.15) | 2.87 (0.11) | 2.87 (0.08) | 2.84 (0.07) | 2.64 (0.04) |
| June 2020 | 2.69 (0.14) | 2.61 (0.10) | 2.67 (0.08) | 2.42 (0.06) | 2.34 (0.04) |

Note: Period: January 2019 to June 2020.

Table 2 Age-SDR per 100 000 person-days () in the municipalities of the Lombardy region grouped according to quintiles of average pension of the resident population aged 65 and over

| Month | Groups of municipalities defined by quintiles of average pension | | | | |
|----------------|--|--------------------|--------------------|--------------------|--------------|
| | 1 (<€15 333) | 2 (€15 333–16 672) | 3 (€16 673–17 762) | 4 (€17 763–18 965) | 5 (≥€18 966) |
| January 2019 | 13.48 (0.62) | 14.96 (0.50) | 13.83 (0.38) | 13.82 (0.35) | 12.64 (0.18) |
| February 2019 | 15.00 (0.69) | 14.54 (0.52) | 15.76 (0.43) | 13.63 (0.37) | 12.87 (0.19) |
| March 2019 | 13.39 (0.62) | 12.57 (0.46) | 12.26 (0.36) | 12.23 (0.33) | 10.93 (0.17) |
| April 2019 | 11.35 (0.58) | 11.21 (0.44) | 11.30 (0.35) | 10.66 (0.31) | 10.22 (0.16) |
| May 2019 | 11.47 (0.57) | 10.67 (0.42) | 10.21 (0.33) | 10.39 (0.3) | 9.92 (0.16) |
| June 2019 | 12.32 (0.60) | 10.67 (0.43) | 11.16 (0.35) | 10.98 (0.32) | 10.37 (0.17) |
| July 2019 | 9.94 (0.54) | 11.73 (0.44) | 10.34 (0.33) | 11.16 (0.31) | 9.94 (0.16) |
| August 2019 | 10.32 (0.55) | 10.73 (0.43) | 9.87 (0.32) | 10.19 (0.3) | 9.47 (0.16) |
| September 2019 | 10.40 (0.56) | 9.98 (0.42) | 10.18 (0.33) | 9.90 (0.3) | 9.24 (0.16) |
| October 2019 | 11.77 (0.58) | 10.85 (0.43) | 11.00 (0.34) | 11.19 (0.31) | 10.06 (0.16) |
| November 2019 | 11.35 (0.58) | 11.88 (0.46) | 11.29 (0.35) | 10.82 (0.31) | 10.61 (0.17) |
| December 2019 | 12.80 (0.61) | 12.52 (0.46) | 11.94 (0.36) | 11.94 (0.32) | 10.82 (0.17) |
| January 2020 | 12.71 (0.60) | 12.72 (0.46) | 12.68 (0.36) | 12.01 (0.32) | 11.35 (0.17) |
| February 2020 | 14.13 (0.65) | 12.72 (0.47) | 12.93 (0.38) | 12.50 (0.34) | 11.37 (0.17) |
| March 2020 | 46.09 (1.13) | 52.03 (0.91) | 43.75 (0.66) | 36.62 (0.55) | 25.33 (0.25) |
| April 2020 | 26.14 (0.87) | 25.29 (0.65) | 24.69 (0.51) | 23.18 (0.45) | 21.20 (0.23) |
| May 2020 | 12.00 (0.58) | 12.00 (0.45) | 11.17 (0.34) | 11.02 (0.31) | 10.56 (0.16) |
| June 2020 | 9.31 (0.52) | 10.54 (0.42) | 10.10 (0.33) | 9.91 (0.30) | 9.04 (0.15) |

Note: Period: January 2019 to June 2020.

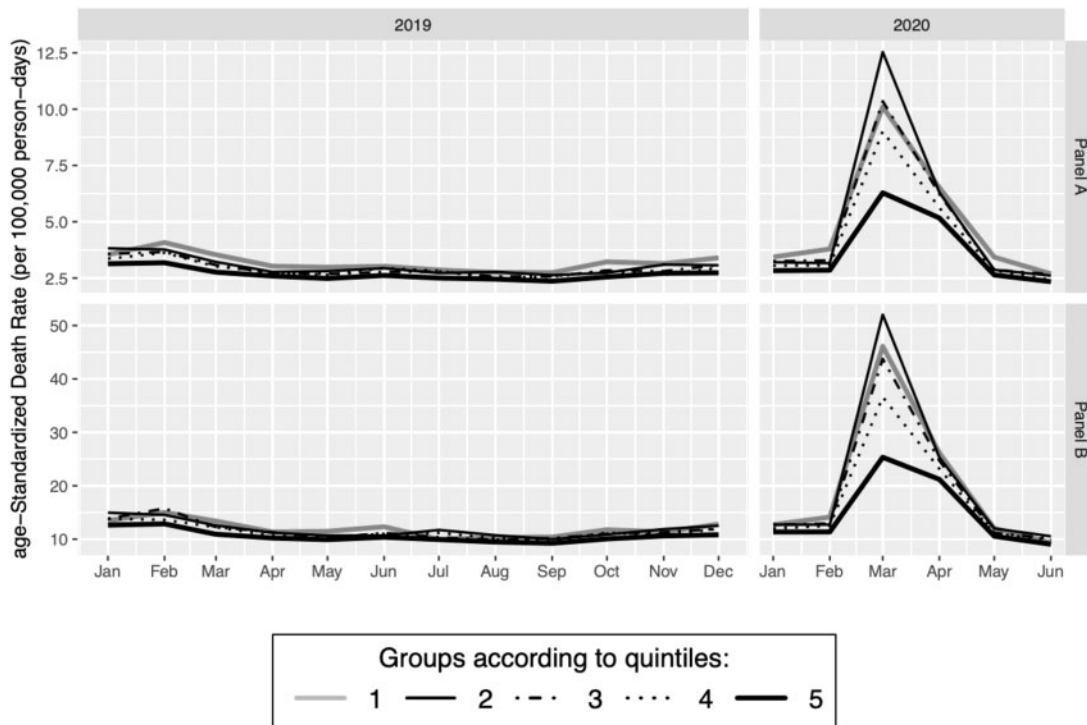


Figure 1 Monthly trend in age-standardized mortality rates (per 100 000 person-days) at all ages (A) and at ages 65 and over (B) in municipalities grouped according to quintiles of average income (A) or pension (B) of the resident population. Lombardy region, period: January 2019 to June 2020

the closing of many economic activities, leaving open only essential services. Thus, workers in essential sectors, including retail grocery, delivery workers, public transport employees, police and military personnel, factory and farm workers continued to have close contact with co-workers and customers during the pandemic. Consequently, those workers and their relatives, who are more likely to live in the poorest areas, had been exposed to a high risk of infection. Some essential workers live in the municipalities in the second fifth of the income distribution, and this may also explain the largest excess mortality found in these municipalities. Third, people living in poor areas are generally low educated with less health literacy and may have been less compliant to the protective measures

implemented by the Government.^{13,14} Finally, important health disadvantages of people with low socioeconomic position have been previously detected in Italy and in other countries.^{15–18} People in low socioeconomic position have a higher prevalence of chronic conditions, including chronic obstructive pulmonary diseases,¹⁹ cardiovascular diseases²⁰ and diabetes,²¹ all important risk factors for more severe forms of COVID-19.²²

In April 2020, mortality remained higher than that observed in the same month of the previous year in all municipalities. However, the observed disparities returned to the levels observed in the pre-pandemic period, likely due to the implementation of an effective surveillance system, and a reorganization of hospital

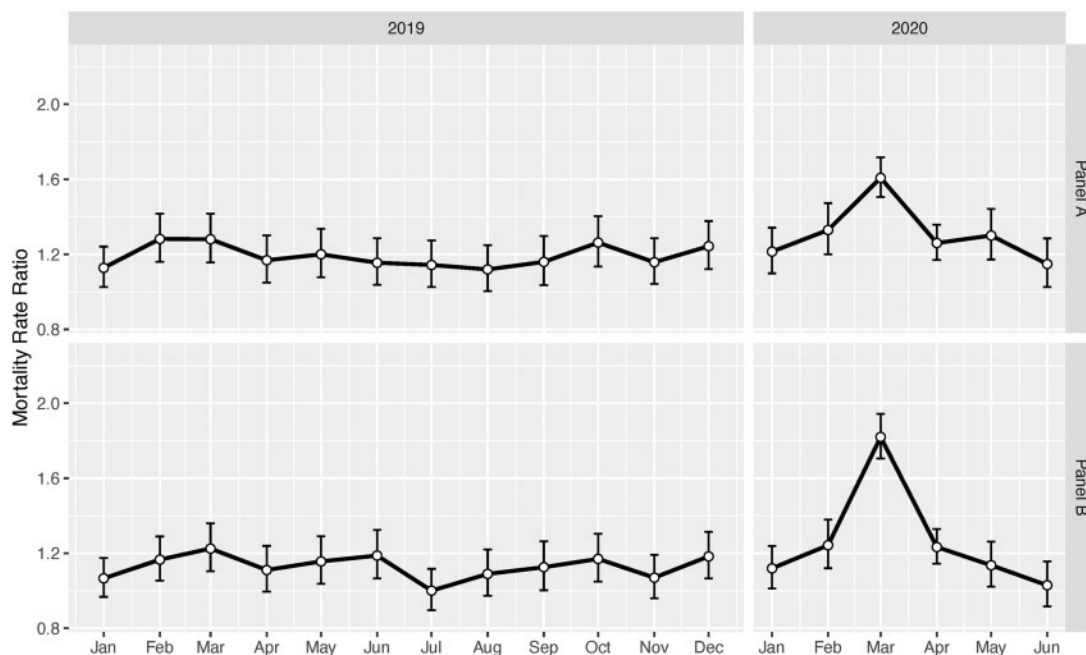


Figure 2 Age-standardized MR between the municipality grouped into the lowest and the highest fifth of the average income (A) or pension (B) of the resident population. Lombardy region, period: January 2019 to June 2020

care, particularly emergency and intensive care units that may have contributed to decrease the inequalities observed in the first month of the pandemic.

Our results should be interpreted in the context of an ecological study, where the mechanisms underlying the associations between living in poor areas and mortality during the COVID-19 pandemic can only be hypothesized. In that regard, we found a higher mortality in municipalities in the second-fifth of income and pension distribution as compared with the poorest ones. In addition, most municipalities in the lowest fifth of the income distribution were small and peripheral with limited ability to provide the population with adequate access to care. This suggests that other indicators, beyond the level of income, have likely contributed to the geographic differences in mortality during the pandemic. Indeed, other individual and area-level variables, such as the number of contacts, mobility, compliance with the physical distancing measures, presence of comorbidities, availability of specifically trained healthcare personnel, ICU beds and ventilators to care for critically ill patients could have been useful in shed some light on the difference impact that the COVID-19 had in our country.

Still, our study provides unique data on the socioeconomic differences in total mortality during the hardest period of the pandemic, in a region where the healthcare system has long considered world class, but it was not adequately prepared to face with this unprecedented event. Our data are also important in view of the economic crisis that will follow the pandemic and the measures adopted to control it, which are expected to further increase the pre-existing.²³ After the financial crisis of 2008, morbidity and mortality from psychiatric disorders, suicide, alcohol and substance-related deaths disproportionately increased among people in low socioeconomic position.^{24,25} Thus, specific interventions targeted to these high-risk individuals are needed to avoid further worsening of their health in the second phase of the pandemic and in the recovery period.

We evaluated mortality from any cause rather than mortality due to COVID-19 since cause-of-death data for 2020 were not available in our country yet. However, total mortality, in this case, is a valid indicator to quantify the overall impact of the COVID-19 since it allows to consider also the deaths occurred among people who died untested and untreated. Indeed, at the beginning of the pandemic,

only a limited number of molecular tests had been performed among people with severe symptoms requiring hospitalization. Conversely, total mortality includes also the deaths not directly caused by SARS-CoV-2 infection but resulting from the reduced seeking for medical care due to the fear of contracting the infection in hospitals and more importantly, the disruption of the healthcare system during the pandemic with a potential negative impact on the mortality from other diseases.^{26,27} This was particularly true in March, when the healthcare system was unprepared to face the crisis and was forced to shift resources from those allocated for the care of other diseases. This has reduced the ability of providing people with adequate and timely treatment, eventually resulting in excess mortality from diseases other than the COVID-19.^{28,29}

In conclusion, socioeconomic widening during the pandemic in one of the first and most severely hit region in Europe. Continuous and timely monitoring of mortality in small areas should be a first step to avoid further and unequal increase in mortality.

Data availability statement

The datasets used in this study were derived from sources in the public domain:

- Istituto Nazionale di Statistica. Decessi e cause di morte: cosa produce l'ISTAT. URL <https://www.istat.it/it/archivio/240401>
- Ministero dell'Economia e delle Finanze. Dati su base comunale: redditi e principali variabili IRPEF—anno d'imposta 2018. URL https://www1.finanze.gov.it/finanze3/analisi_stat/v_4_0_0/contenuti/Redditi_e_principali_variabili_IRPEF_su_base_comunale_CSV_2018.zip

Supplementary data

Supplementary data are available at *EURPUB* online.

Conflicts of interest: None declared.

Key points

- Lombardy was the Italian region most affected during the first phase of the COVID-19 pandemic.
- During the first phase of the pandemic, total mortality was substantially higher in the poorest municipalities of the region and socioeconomic inequities widened.
- Timely mortality data are needed to monitor further and unequal increase in mortality .

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