Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

CHAPTER

2.1

Estimation of mortality and severity of the Covid-19 epidemic in Italy

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2.1.1 Introduction

Starting from the first case recorded, information on the spread of Covid-19 in Italy is communicated daily by the institutions. The number of deaths related to Covid-19 is provided by the ISS (Istituto Superiore di Sanità—Italian Higher Health Institute) but only at the regional level and by age at the national level. At present, information on the age of deceased persons at regional level has not yet been given. Also, during the most critical phase of contagion, several people died without a swab test that would have established whether they had contracted the virus. For these reasons, we decided to analyze death rates using ISTAT (Italian Office of Statistics) mortality tables.

In October 2020, ISTAT published a note (ISTAT, 2020) which reported up-to-date data on deaths from all causes in Italy by municipality and by age in the first 8 months of the year from 2015 to 2020. While in July 2020 ISTAT (ISTAT, Istituto Superiore di Sanità, 2020c) table which addressed almost all of the Italian territory, 87% of the 7904 Italian municipalities and 86.4% of the inhabitants, the updated report they covered the entire territory and all the Italian population. ISTAT issued a first report on mortality in May 2020 (ISTAT, Istituto Superiore di Sanità, 2020a), followed by a second report (ISTAT, Istituto Superiore di Sanità, 2020b) published in June 2020.

In the last published report, ISTAT (ISTAT, 2020) provided data relating to all the subjects who died daily in Italy by municipality and by age in the first 8 months of the year from 2015 to 2020: these are the data we consider in this study, along with data provided by the ISS on Covid-19-related deaths established via swab tests.

We propose to estimate mortality by region and by age group due to both Covid-19 and causes attributable to Covid-19. This estimate is compared to deaths from other causes, or mortality that we would have expected to observe without the impact of the disease.

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The aim is to understand the impact that the epidemic had in the different regions and in the different age groups. In fact, by comparing mortality rates in 2020 and in previous years (from 2015 to 2019) with the official number of Covid-19-related deaths, it is possible to observe an excess of deaths in some geographical areas and for some age groups.

ISTAT (ISTAT, Istituto Superiore di Sanità, 2020a) states that this excess may be attributed to three causes: additional mortality due to Covid-19 (deaths in which a swab test was not performed); indirect mortality associated with Covid-19 (deaths from organ dysfunction for the heart or kidneys caused by disease triggered by the virus in untested people) and, finally, an indirect mortality rate unrelated to the virus but caused by the meltdown of the public health system and the reluctance of patients to undergo hospitalization in the most affected areas.

ISTAT mortality tables, and other official mortality data disclosed by the ISS, have been widely addressed in the literature and the severity of the Italian situation emerges clearly in all the articles.

Along these lines, Modi et al. (2020) performed counterfactual analysis of the historical series on the 2020 mortality data using control data provided by ISTAT on the previous 5 years. They found that excess mortality significantly exceeds official Covid-19 death rates. They suggest that there is a large amount of people, mostly elderly, missing from official mortality statistics. They estimate the case mortality rate (CFR), the death rate from infection (IFR), the population death rate (PFR), and the infection rate (IR). Finally, they note that the estimation of IFR and IR is very difficult due to uncertainties in the official Covid-19 death rate.

Buonanno et al. (2020) provide new results on the misreported mortality level for Lombardy and the Bergamo province using both official and original data sources. By combining official statistics, retrospective data, and original data (i.e., obituaries and death notices) they compare the official number of deaths reported in March 2020 with those reported in the same month in the previous year in a sample of Lombard municipalities.

Marino and Musolino (2020) focus on ISTAT mortality tables to compare official and "hidden" Covid-19 mortality. They indicate that several people with the disease died at home without being tested. They observe a significant difference between official and "hidden" mortality in Lombardy, especially in some of its provinces such as Bergamo and Brescia, while this difference is smaller for the Center and even lower for Southern Italy.

Bucci et al. (2020) underline the fact that the deaths may be divided into direct and indirect related to Covid-19, where indirect deaths are due to an overload of the health system. They show that the official figures underestimate the number of deaths, especially in the most affected areas. In their study, they focus on Lombardy, Liguria and Emilia-Romagna using an older dataset and with fewer data than the present model. They use gender imbalance to estimate disease-related death. They separate expected deaths in a normal situation, with deaths related either directly or indirectly to Covid-19.

Murgante et al. (2020) estimate the number of deaths expected in the Italian provinces from the sum for each age of the population of a specific age in each province multiplied by the national mortality rate for that specific age. The standardized death rate is then estimated by comparing the number of events recorded in each province with the respective number of expected events.

Along these lines, our goal is to assess mortality attributable to Covid-19 and to other causes by charting age-specific estimates for each region. We therefore propose to estimate mortality rate using both official data sources: Covid-19-related mortality in all regions provided by the ISS and overall mortality (therefore both from Covid-19 and from other causes) provided by ISTAT. For the purposes of our research, we will consider the population death rate provided by ISTAT as of 1 January 2019.

Analyzing and comparing the situation in Italy and in other countries, several authors have laid out a range of hypotheses to account for different mortality levels.

Yuan et al. (2020) focus on transmissibility and mortality of Covid-19 in Europe and report real-time, actual reproduction numbers and case fatality rates in Europe by using data from the World Health Organization website.

Fanelli and Piazza (2020) analyze the temporal dynamics of the Covid-19 outbreak in China, Italy, and France, within the time frame 22/01–15/03/2020, the initial phase in Italy and France. Analysis of the same data within a simple susceptible infected-recovered-deaths model indicates that the recovery rate does not seem to depend on the country, while the infection and death rate show a more marked variability.

Onder et al. (2020) indicate that the fatality rate in the Italian population, based on data up to March 17, 2020, was 7.2%. This rate is higher than the one recorded in other countries and may be related to three factors. The demographics of the Italian population differ from other countries, so the older age distribution in Italy may partly explain Italy's higher case-fatality rate compared to other countries. A second possible explanation may have to do with the way in which Covid-19-related deaths are identified in Italy. Covid-19-related deaths as those occurring in patients who test positive for Covid-19, regardless of pre-existing diseases that may have caused death. A third possible explanation are the differing strategies used for Covid-19 testing. After an initial, extensive testing strategy of both symptomatic and asymptomatic contacts of infected patients in a very early phase of the epidemic, on February 25, 2020, the Italian Ministry of Health issued more stringent testing policies, mandating testing only for patients with more severe clinical symptoms who were suspected of having Covid-19 and required hospitalization.[a]

Medford and Trias-Llimós (2020) explore differences in age distribution of deaths from Covid-19 among European countries by a cross-country comparison of age distribution and put forward some reasons for potential differences. They analyze the situation in France, Italy, the Netherlands, and Spain with a cross-country comparison of age-patterns in observed Covid-19 death counts and their counterfactual distribution adjusted by the age-structure of Italy. Italy has the oldest population in Europe, but proportionately fewer deaths from Covid-19 at older ages are found in Italy than in either Spain, France, or the Netherlands.

This chapter is laid out as follows. The first section features an analysis of mortality in March 2020 in Italy; the second provides estimates for deaths directly or indirectly attributable to Covid-19; the third reports previous estimates divided by age; and the last section is devoted to conclusions.

[a]For more details, see Chapter 5 of this volume.

2.1.2 Mortality in Italy in March 2020

According to ISTAT mortality tables (ISTAT, 2020), in March 2020 85,786 people died in Italy against an average of 58,265 over the previous 5 years. As shown in Table 2.1, the region where the death toll was higher than the average number of deaths recorded in the previous 5 years for the same period is Lombardy. Virtually one third of the people who died in Italy in March 2020 were in Lombardy. While some regions (such as Aosta Valley, Molise, or Basilicata) show very low absolute numbers, it would be erroneous to conclude that Covid-19 had a minor impact in them.

If we analyze the percentage change in deaths in March 2020 from Table 2.1, and compare it to the average death toll in March over the previous 5 years, we notice that Lombardy presents the largest variation with an increase of almost 191 deaths. It may be concluded that the

TABLE 2.1 Total deaths in March 2020; average death rate over the previous 5 years in the same period; and percentage change (calculated from ISTAT mortality data).

Total deaths	2020	2015–2019	% variation
Piedmont	7240	4740	52.74%
Aosta Valley	205	134	52.99%
Liguria	3024	1970	53.50%
Lombardy	25,560	8778	191.18%
Trentino-South Tyrol	1415	872	62.27%
Veneto	5413	4457	21.45%
Friuli-Venezia Giulia	1519	1353	12.27%
Emilia-Romagna	7748	4582	69.10%
Marche	2328	1620	43.70%
Tuscany	4511	3998	12.83%
Umbria	1043	963	8.31%
Lazio	5384	5245	2.65%
Campania	5083	5026	1.13%
Abruzzo	1557	1372	13.48%
Molise	371	361	2.77%
Apulia	4011	3599	11.45%
Basilicata	571	598	−4.52%
Calabria	1972	1907	3.41%
Sicily	5117	5149	−0.62%
Sardinia	1714	1541	11.23%
ITALY	*85,786*	*58,265*	*47.23%*

deaths in Lombardy almost tripled: for every 100 deaths in March last year, 291 were observed this year (2020). That is followed by Emilia-Romagna, Trentino-South Tyrol, Liguria, Aosta Valley, and Piedmont, where the percentage change is greater than the percentage change recorded in Italy, which is 47%. The regions where the change was lower, if not negative, are Basilicata, Sicily, Campania, Molise, and Calabria.

We may conclude that in Aosta Valley, although the absolute number of deaths is low, the impact of Covid-19 was greater than in other regions which show higher absolute numbers.

This fact is also confirmed by a mortality rate calculation. The death rate for each region in March 2020 is calculated as the ratio between the deaths in March 2020 and the population residing in that region on January 1, 2019. The number obtained is multiplied by 100,000 to obtain the number of deaths for each 100,000 inhabitants. Table 2.2 shows the mortality rates in March for each region calculated in 2020, compared to the same rate calculated on

TABLE 2.2 Mortality rate for each 100,000 inhabitants in March 2020 and average deaths over the previous 5 years in the same period (calculated from ISTAT mortality data).

Mortality rate each 100,000 inhabitants	2020	2015–2019
Piedmont	166	109
Aosta Valley	82	53
Liguria	195	127
Lombardy	254	87
Trentino-South Tyrol	132	81
Veneto	110	91
Friuli-Venezia Giulia	125	111
Emilia-Romagna	174	103
Marche	153	106
Tuscany	121	107
Umbria	118	109
Lazio	92	89
Campania	88	87
Abruzzo	119	105
Molise	121	118
Apulia	100	89
Basilicata	101	106
Calabria	101	98
Sicily	102	103
Sardinia	105	94
ITALY	*142*	*96*

the average number of deaths in March over the 5 years preceding 2020, again divided by the population of 1st January 2019.

In 2020 the death rate in Italy rose noticeably to 142 per 100,000 inhabitants from 96 in previous years. Also, the increase that occurred in all regions has a very different dimension from region to region, placing Lombardy as the region with the highest mortality rate, equal to 254 deaths per 100,000 inhabitants.[b]

As regards the mortality rate, within the Lombardy region the situation is very different by province and this will be explored in Chapter 2.2.

2.1.3 Mortality estimation for Covid-19

Starting from these March mortality data and the data reported by the ISS on deaths from Covid-19 in the regions, we decided to estimate the impact that Covid-19 had on mortality in the various regions of Italy. Our aim is to estimate the number of deaths from all causes attributable to Covid-19. We call it "number of deaths due to Covid+", where the + stands not only for deaths due to Covid-19, but also for the other three causes related to the presence of the virus in the Italian territory. We denote this number with C^+_{re}, where r stands for the geographic area and e denotes the age group. The estimate is done before marginally in each region of Italy. In this phase the estimate of both $C^+_{r.}$ and $C^+_{.e}$ is calculated, respectively the total number of deaths in the area r and the total number of deaths in the age group e. Then, the value of C^+_{re} is estimated for any area r and for any age group e. Let D_{re} denote the number of deaths in area r and in the age group e and G_{re} the number of deaths due to other causes not attributable to Covid-19 in area r and in the age group e. We have the following equality: $D_{re} = G_{re} + C^+_{re}$. Let C^{ISS}_{re} be the number of official deaths from Covid-19 in area r and age e. This last number is not given by the ISS. Indeed, $C^{ISS}_{r.}$ and $C^{ISS}_{.e}$, respectively, the total deaths for Covid-19 in the area r and in the age class e, are known and provided by ISS but, unfortunately, they underestimate the deaths for Covid-19 in some areas and for some age's classes.

Starting from the marginal, the deaths due to Covid+ for each age e is the difference between the total deaths for that age $D_{.e}$ and $G_{.e}$. This last number is estimated by the mean of deaths in the previous years for the age class e. Accordingly, for each age e:

$$C^+_{.e} = \begin{cases} D_{.e} - G_{.e}, \textit{ if } D_{.e} - G_{.e} > C^{ISS}_{.e} \\ C^{ISS}_{.e}, \textit{ otherwise} \end{cases}$$

where $C^+_{.e}$ are the deaths for Covid+ for the age e.

If we move on to an analysis of each area r, we find that the total deaths for Covid+ for each area r is the difference between the deaths in that area $D_{r.}$ and $G_{r.}$. This last number is estimated by the mean of deaths in the previous years in the area r. Accordingly, for each area r we define:

[b] These results are coherent with the analyses on the spread of the Covid-19 infection developed in Chapter 1 of this volume.

$$C^{+}_{r.} = \begin{cases} D_{r.} - G_{r.}, \textit{ if } D_{r.} - G_{r.} > C^{ISS}_{r.} \\ C^{ISS}_{r.}, \textit{ otherwise} \end{cases}$$

where $C^{+}_{r.}$ are the deaths for Covid + in area r.

Once the marginals have been estimated it is possible, at a first stage, to estimate the C^{+}_{re}, which indicates the deaths for Covid + in the area r and for age e, such as:

$$C^{+}_{re} = \begin{cases} D_{re} - G_{re}, \textit{ if } D_{re} - G_{re} > 0 \\ 0, \textit{ otherwise} \end{cases}$$

Accordingly, C^{+}_{re} for each age e and for each area r is the difference between deaths D_{re} and G_{re}. This last number is estimated with the mean of deaths in the previous years in the area r and for the age class e.

C^{+}_{re} must be adjusted according to the estimated marginal. For an age class e $\sum_{r=1}^{R} C^{+}_{re} < C^{+}_{.e}$ or for a geographical area $\sum_{e=1}^{E} C^{+}_{re} < C^{+}_{r.}$, we have an underestimation of deaths for Covid-19. Therefore, if the sum for each area or for each age is not greater or equal to the total deaths for Covid + for that area or for that age class just estimated (our constraints), the estimate for that age class and for that area must be updated.

Starting from the total deaths for Covid + for each age e, if $\sum_{r=1}^{R} C^{+}_{re} < C^{+}_{.e}$, the new estimate indicated with $C^{+\prime}_{re}$ becomes for any r:

$$C^{+\prime}_{re} = C^{+}_{re} + \left(C^{+}_{.e} - \sum_{r=1}^{R} C^{+}_{er} \right) \frac{C^{+}_{r.}}{C^{+}_{..}}$$

where $C^{+}_{..}$ indicated the sum of deaths for Covid + in Italy. In accordance with the formulation the excess deaths for these ages are divided by the proportion of deaths for Covid + in that area over the total deaths for Covid + in Italy. This formula is used for each age except for the last one E, the oldest group, where in each area, it is possible to observe an excess of deaths. Then the value for the last age is obtained by the difference: $C^{+\prime}_{rE} = C^{+}_{r.} - \sum_{e=1}^{E-1} C^{+\prime}_{er}$, so the total deaths by area does not change.

Concerning the total deaths for Covid + in each area r, if $\sum_{e=1}^{E} C^{+}_{re} < C^{+}_{r.}$ we estimate the deaths for Covid + for each age class e starting from the oldest ages using this formulation, for any e:

$$C^{+\prime\prime}_{re} = C^{+\prime}_{re} + \left(C^{+}_{r.} - \sum_{e=1}^{E} C^{+\prime}_{re} \right) * \left(\frac{C^{ISS}_{.e}}{P_{.e}} \right) * P_{re}$$

where P_{re} indicates the inhabitants in the area r for the age e and $P_{.e} = \sum_{r=1}^{R} P_{re}$ indicates the Italian inhabitants for the age e and we stop to update this value when $\sum_{e=1}^{E} C^{+}_{re} = C^{+}_{r.}$. According to this formulation, we divide the excess of deaths between the age's classes starting from the oldest classes (the most affected by Covid-19) using the Italian mortality rate multiplied by the inhabitants in that area for that age class e.

Once the deaths for Covid + are estimated for each area r and for each age e, the sum of deaths for each age $C^{+\prime\prime}_{.e}$ is updated. This value will be greater than $C^{+}_{.e}$ as we add new deaths in the ages starting from the oldest subjects, the most affected.

Lastly, the values G_{re} are updated, as D_{re} is fixed, we have just estimated C_{re}^{+} and, accordingly, we obtain by difference the new values of $G_{re} = D_{re} - C_{re}^{+}$''.

In this section we consider the mortality data in each region of Italy in March 2020. The death rate for Covid+ is then calculated by dividing the estimated deaths, obtained using the above method, by the population residing in that region on 1st January 2019.

In Table 2.3 and Fig. 2.1, the estimated mortality rate from direct and indirect causes of Covid-19 (Covid+) is compared with the death rate due only to Covid-19, according to

TABLE 2.3 The mortality rate for each 100,000 inhabitants estimated for Covid+ and mortality rate due only to Covid-19 and total deaths for Covid+ and Covid-19 (calculated from ISTAT mortality data).

	Mortality rate Covid+	Mortality rate Covid-19	Deaths for Covid+	Deaths for Covid-19	Covid+/ Covid-19
Piedmont	57	23	2501	1018	2.46
Aosta Valley	56	56	71	70	1.01
Liguria	68	24	1055	368	2.87
Lombardy	167	83	16,782	8339	2.01
Trentino-South Tyrol	51	26	543	281	1.93
Veneto	20	10	957	509	1.88
Friuli-Venezia Giulia	14	5	166	57	2.91
Emilia-Romagna	71	42	3166	1886	1.68
Marche	46	22	709	328	2.16
Tuscany	14	6	513	226	2.27
Umbria	9	4	80	37	2.16
Lazio	3	3	158	158	1.00
Campania	1	1	79	79	1.00
Abruzzo	14	5	185	64	2.89
Molise	3	1	10	4	2.50
Apulia	10	3	412	118	3.49
Basilicata	1	1	5	5	1.00
Calabria	3	1	65	18	3.61
Sicily	2	2	77	77	1.00
Sardinia	11	2	173	39	4.44
ITALY	*46*	*23*	*27,707*	*13,681*	*2.03*

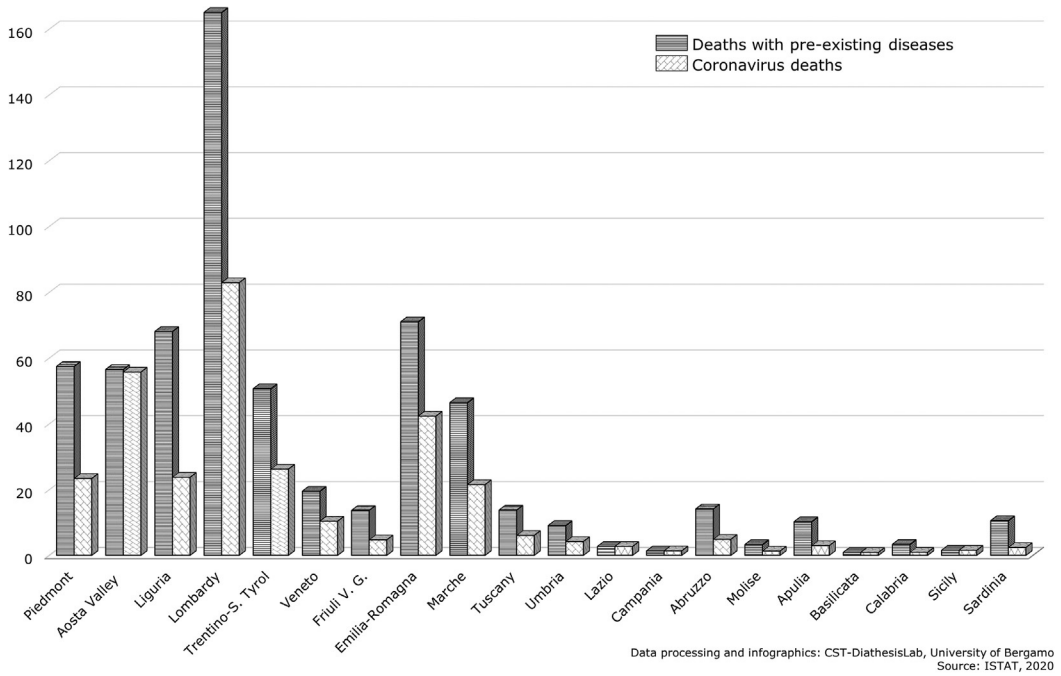

FIG. 2.1 Mortality rates in March 2020 for Covid-19 and Covid+ by region (estimates from ISTAT mortality data).

data released by the ISS. We can see that this value in Lombardy is almost double, which indicates that for every Covid-19 death certified by a swab test there is another death attributable to Covid-19 for direct or indirect reasons. Analyzing the relationship between Covid+ and Covid-19 it is possible to observe even higher values in other regions, such as in Sardinia, where this ratio is higher than 4 but linked to very low mortality values.

Fig. 2.2 shows an anamorphic map in which the surface is distorted (dilated or contracted) based on the number of inhabitants for each municipality on the 1st January 2019, which makes it possible to highlight the most populous areas. The number of deaths from Covid+ in March 2020 is color-coded, while circles are used to indicate the death rate for Covid+ per 100,000 inhabitants in each region. This reflexive cartography model—which presents localized and cross-referenced data—allows us to interpret mortality in its impact on population and on its regional distribution in a detailed and, at the same time, comparable view. This recovers the social impact of epidemic mortality and promotes a search for the possible causes of these differences in other socio-territorial data such as type of settlement, mobility, pollution or other.

An analysis of the regional level modified by the number of inhabitants shows that Lombardy, Lazio, and Campania are dilated in relation to the high population density of the metropolitan cities of Milan, Rome, and Naples that they enclose. The other regions are distorted with respect to their topography, because within them the municipalities are skewed according to the number of residents.

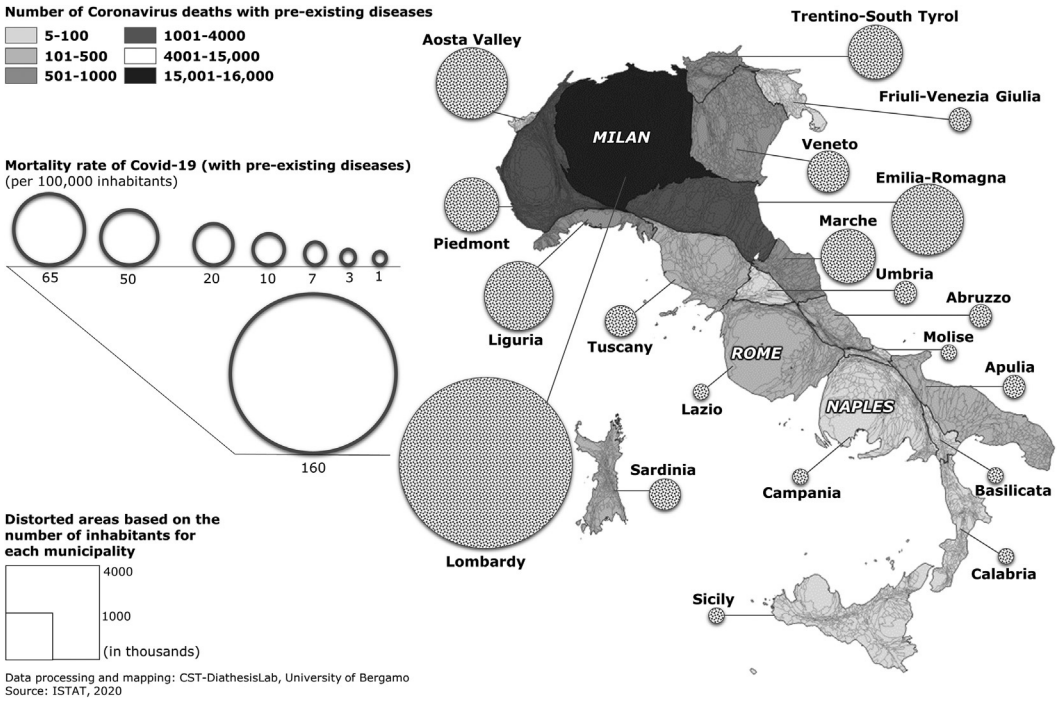

FIG. 2.2 The number of deaths and mortality rate for Covid+ in March 2020.

Once again, the map indicates that Lombardy has the highest death rate from Covid+ (circle with the largest diameter) and the highest number of deaths (given by the gray color in the darkest shade). In Aosta Valley there is a high mortality rate value (marked by a larger circle) but a low number of deaths (color-coded in light gray). It means that the impact of the disease in this region with few inhabitants was high, for even though the absolute number of deaths is low, the death rate is high.

In other regions, such as Emilia-Romagna and Piedmont, we have a high number of deaths (color-coded in dark gray) but a lower mortality rate (circle with a smaller diameter than that of Lombardy). In Liguria, Veneto, and Marche there are several deaths (−coded in gray) but with different mortality rates, lower in Veneto, with a smaller circle, compared to the other two regions. Tuscany, Lazio, Abruzzo, Apulia, and Sardinia show fewer deaths (−coded in light gray) linked also to a low mortality rate (smaller circle).

2.1.4 Analysis of mortality by age

In this early stage of the epidemic, the spread of Covid-19 had a different impact on different age groups. To analyze this disparity, we estimated the mortality rate for each age group. Covid-19 impact on people under the age of 60 is virtually negligible compared to impact in older age groups. Consequently, Fig. 2.3 shows a map of Italy where basemap colors

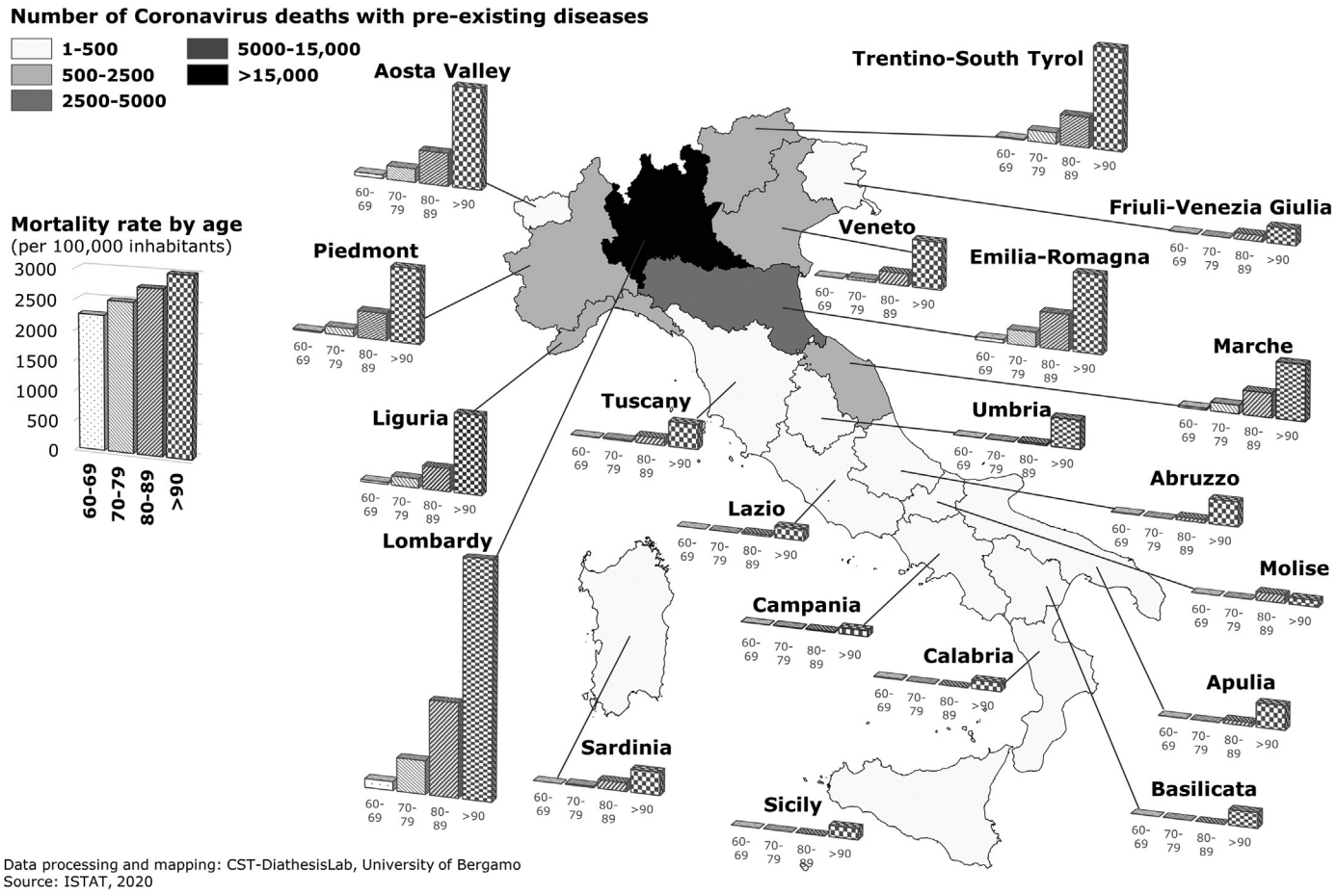

FIG. 2.3 Mortality rate for Covid+ by region and by age in March 2020.

TABLE 2.4 Number of total deaths in March 2020, and deaths for Covid+ and Covid-19 by age (ISS and estimated from ISTAT mortality data).

Number of deaths	0–9	10–19	20–29	30–39	40–49	50–59	60–69	70–79	80–89	≥90	Total
Total	127	62	123	282	1023	3081	7141	18,165	34,353	21,429	85,786
Covid+	0	0	2	25	129	621	1916	6546	11,606	6862	27,707
Covid-19	0	0	2	25	92	409	1271	3724	4366	1051	10,940

(color-coded in gray) provide the total number of estimated deaths due to Covid+ in March 2020, while the death rate is reported in the bar plot for people aged 60 or older.

It may be observed that the older class (aged 90 or over) is the most affected. In fact, each region for this class presents the highest graph bar.

An analysis of the impact by age in each region indicates once again that Lombardy is the region most severely affected by the disease. Lombardy shows, in fact, the highest number of deaths (color-coded in black) and the highest mortality rate graph bar in each age group.

As already pointed out, Aosta Valley shows severe Covid-19 impact even with a low number of deaths: its area is color-coded as white to mark a low number of deaths, but graph bars are higher for each age group. Piedmont, Trentino-South Tyrol, Emilia-Romagna and Liguria show fairly high graph bars but a medium number of deaths (color-coded in light gray) with the exception of Emilia-Romagna (color-coded in dark gray), the second region for a number of deaths. For the Veneto and Marche regions, we observe a low number of deaths (light gray) and lower graph bars. In the other regions, there is a lower number of deaths (color-coded in white) and lower graph bars, except for the last bar that refer to the oldest age group. This last bar is higher in Sardinia, Tuscany, Umbria, Abruzzo, and Apulia than in other regions.

It should be emphasized that in the case of people over 70 years of age, Covid-19 is responsible for approximately one in three deaths, with 73,947 total deaths in March 2020 and 25,014 deaths from Covid+ (as shown in Table 2.4).

It should also be noted that the total number of deaths provided by ISS in Table 2.4 differs from the number given in Table 2.3. This last number is 2741 units greater than the first. Unfortunately, since the October 2020 ISTAT report (ISTAT, 2020) failed to include data on deaths for Covid-19 for age, we resorted to using the latest data provided by the ISS for 31/03/2020, available online.[c]

2.1.5 Conclusions

In this section we have considered data provided by ISTAT on mortality in Italy in the first quarter of 2020, focusing only on the month of March 2020, i.e., in the first and most severe phase in which Italy was faced with the emergence of the new SARS CoV-2 virus responsible for the Covid-19 disease.

[c] https://www.epicentro.iss.it/coronavirus/bollettino/Infografica_31marzo%20ITA.pdf.

Since there is a lack of information on age-related mortality by region, especially in regions, such as Lombardy, where the impact of Covid-19 was significant, we have estimated the mortality and mortality rate by combining data given by the ISS with those given by ISTAT for March 2020 and for the same month from 2015 to 2019, a year range used for comparison or control.

The conclusions are that the impact of the Covid-19 disease in Italy was severe, but Lombardy was the region that, in addition to the highest absolute numbers of deaths, revealed the highest rates of variation and the greatest mortality.

Similar conclusions may be drawn from official data, which confirm that Lombardy had the highest death rates. However, official data fail to quantify the impact this disease had on mortality. In fact, the mortality statistics compiled with our method indicate that the death toll was nearly double the one officially reported by the ISS, even though that was already high compared to mortality recorded for the same March period over the previous 5 years. This difference may be related to the fact that a very large number of deaths were not certified as Covid-related via a swab test, and were therefore not computed in the official statistics.

From an analysis of mortality by age, it may be concluded that deaths from direct or indirect Covid-19 causes severely affected people aged 70 years or older. Given that institutions in Italy do not provide information on the age of deceased at regional level, the present study devised a method for estimating this value and for zeroing in on the repercussions of Covid-19 on different age groups. Our study conclusively shows that one in three people aged 70 or over who died in March 2020 died for causes related to the onset of the Covid-19 epidemic.

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