COVID-19: THE EFFECTS OF THE ITALIAN RED ZONES ON MORTALITY

Marco Biagetti, Valentina Ferri

Introduction

Italy and Spain were the first two European countries hardly hit by the Wuhan strain of SARS COV-2. The 2020 Covid-19 first wave was particularly deadly in the Italian region of Lombardy. The region is the most populated in Italy accounting for roughly 17-18% of the total population of the country. Yet, during the first Covid-19 wave (March through early May 2020) official figures show 16,632 deaths in Lombardy (47.7% of the Italian total) a ratio which is significantly higher with respect to what happened in the second and third wave combined (Chirico et al. 2021)[1].

Within Lombardy, Fior and Mpampatsikos (2021) show that the difference of daily deaths that occurred between 2020 (i.e. the period of the first two Covid-19 waves) and the average of the previous five years (i.e., the so-called ‘excess deaths’ by Covid-19), is positive for most of the 622 municipalities they analyze. Only a few municipalities in Como, Varese, and Mantua provinces have a negative balance. The peaks (with a number of deaths greater than 125) are found in the provincial capitals (characterized by a greater number of inhabitants) and between Val Brembana and Val Seriana districts. Then, in the East-West axis (along the A4 highway) that intercept the Franciacorta area, Brescia and the Garda Riviera plains, and the plain between Crema and Cremona. Others are in the East Milanese area and between the municipalities of Bergamo and Brescia's lowlands, where the municipalities of Caravaggio, Treviglio (lower Bergamo Province), and Orzinuovi (Brescia Province) stand out. This is a highly urbanized and very productive territory; from the Bergamo valleys to Brescia's hills. The greatest increase in deaths was found in Bergamo, Lodi, and Cremona Provinces, and the Western part of the Brescia Province, while a sort of vertical axis of contagion running from the Lodi area's southern edges until the city of Bergamo and its entire province could be highlighted.

Most remarkably, some municipalities have seen a 26 times higher increase of deaths compared to the average daily deaths, such as Valbondione, Aprica and Breme. Also Torrazza Coste (Pavia Province), Senna Lodigiana (Lodi Province), Verolavecchia, Corte Franca and Torbole Casaglia (Brescia Province), San Giovanni

[1] In the latter waves, deaths in Lombardy were 15,515 (18.9% of all deaths in Italy).

Bianco and Nembro, Alzano Lombardo, Selvino, Pradalunga (Bergamo Province) stand out.

Overall, those authors show an increase in death toll circumscribed at parts of the above mentioned provinces, particularly in some municipalities and in the first wave. Building on this findings, in what follows this article wants to shed light on the following: a) the increase in daily mortality between February and March 2020 in the municipalities first involved in the first Covid-19 pandemic; b) an increase similar in the Lodi, Bergamo and Cremona provinces; c) a reduction of cases and Covid-19 related excess deaths due to the institutions of the so called Red Zones where strict Chinese-like lockdowns were implemented.

The paper is organized as follows: chapter two reviews literature on Non-Pharmaceutical Interventions (NPI) carried out to tame and tackle Covid-19 outbreaks. Chapter three exhibits the data used and the methodology (difference-in-difference) chosen. Chapter four highlights the introduction of Red Zones. Chapter five shows econometric results, while the last chapter concludes.

2. Literature: NPI interventions on covid-19 outbreaks

Mendez-Brito et al. (2021) have performed a systematic review of published and unpublished empirical studies, and found that early implementation of school or working place closings were associated with a higher effectiveness in reducing COVID-19 cases and deaths, while general stringency of the NPIs was not.

Similar results have been found by Brauner et al. (2020) through the use of a Bayesian hierarchical model. In particular closing schools and universities was highly effective, together with banning gatherings. Closing most other business was had instead limited benefit; that many countries may have been able to reduce R below 1 without issuing a stay-at-home order.

Sharma et al. (2021) evaluate the effects of 17 NPIs on second wave of Covid-19 in Europe again using a hierarchical Bayesian transmission model. Once again, business, school closures, gathering bans reduced transmission but less than they did in the first wave. This difference is likely due to organizational safety measures and individual protective behaviors—such as distancing—which made various areas of public life safer and thereby reduced the effect of closing them.

Liu et al. (2021) evaluated the effectiveness of 13 NPIs for 130 countries and territories using panel regression techniques and hierarchical cluster analyses from January to June 2020. The evidence found was strong for an association between school closures and internal movement restrictions with an R_t reduction. Other NPI like workplace closure had strong evidence of effectiveness on reducing transmission only when the level of intensity was ignored, while the gathering cancellations was effective only when the evaluation was carried out considering maximum capacity (e.g. restrictions on 1000+ people gathering were not effective, restrictions on < 10 people gathering were). Evidence about the effectiveness of the remaining NPIs (stay-at-home requirements, public information campaigns, public transport closure, international travel controls, testing, contact tracing) was inconsistent and inconclusive. The authors found temporal clustering between many of the NPIs. Effect sizes varied depending on whether or not we included data after peak NPI intensity.

Yacong Bo et al. (2021) collected evidence on 4 NPIs (face masks, isolation or quarantine, social distancing, traffic restrictions) for 190 countries between January 23rd and April 13th 2020. Results showed that face masks reduced Rt by 15%, quarantine by 11%, social distancing by 43%, traffic restrictions by 9%. Distancing and the simultaneous implementation of two or more types of NPIs seemed to be associated with a greater decrease in the Rt of COVID-19.

On the other hand Seung-Hun Hong et al. (2021) using a linear regression over 108 countries found that school closures are effective in containing COVID-19 only when they are implemented along with complete contact tracing. Furthermore, the authors suggested that governments should consider implementing prudently designed full contact tracing and school closure policies, among others to contain COVID-19 effectively and minimize the risk of human rights abuses

Along the same lines, Haug et al. (2020) analyzed the issue using a comprehensive, hierarchically coded dataset of 6,068 NPIs implemented in March–April 2020 in 79 territories, through a multi-method approach consisting of (1) a case-control analysis (CC), (2) a step function approach to LASSO time-series regression (LASSO), (3) random forests (RF) and (4) transformers (TF). They found that a suitable combination of NPIs is necessary to curb the spread of the virus. Less disruptive and costly NPIs can be as effective as more intrusive, drastic, ones. Haug also shows that their effectiveness of NPIs depends of course on timing of adoption. Early adoption is always more beneficial: in other words, the earlier the better in terms of curbing spreads of rapidly propagating viruses.

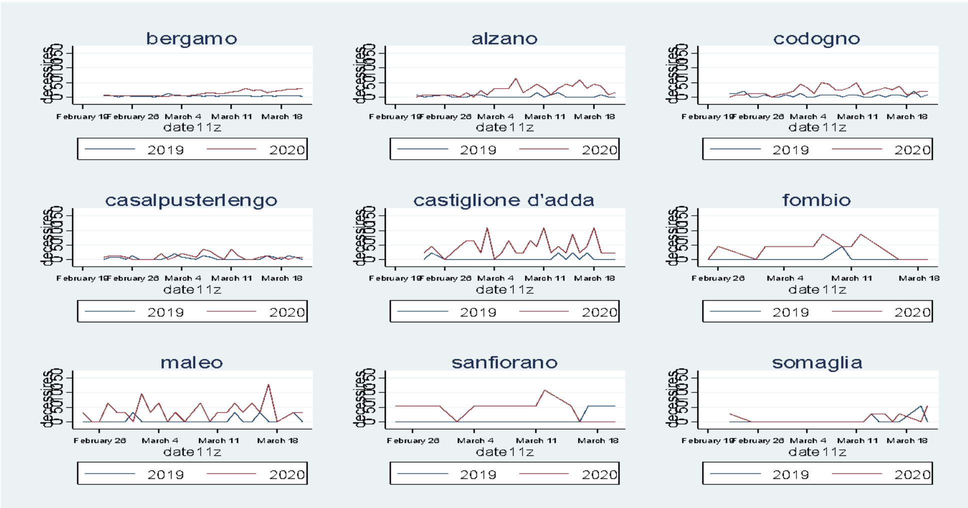
3. Descriptive statistics, data and methodology

Before introducing the data and methodology used, a word of caution needs to be said. Covid-19 related deaths[2] are not available at a municipal level. Nonetheless, were they hypothetically available, their reliability would be questioned. The reason for this unreliability is that when the first European Covid-19 outbreaks appeared, the discrepancy between deaths due to Covid and deaths of people due to other reasons whose tests were found positive (the so called deaths with Covid) was absolutely thin. To circumvent this limitation, we have decided to use data on all-cause daily mortality under the hypothesis that municipalities included in the first

[2] The deaths for which Covid-19 can be considered the main or one of the main causes.

Red Zone established between February 22nd and March 8th 2020 have seen a statistically significant reduction in deaths in the time lapse immediately subsequent to the reopening of the same Red Zone. Even if some may think that this reduction in mortality could have been even higher in the following months, due to the abolition of the same Zone, only the period up to March 23rd can be analyzed. This time limit is mandatory even because after the first delimited Red Zone, another wider Red Zone was established throughout the whole of Lombardy. This would undoubtedly bias our results. In Figure 1 the difference in the deaths count between 2019 and 2020 can be seen for nine municipalities among which Bergamo.

Figure 1 – *Differences between 2019-2020 in some municipalities.*



Source: Authors' elaborations on ISTAT data.

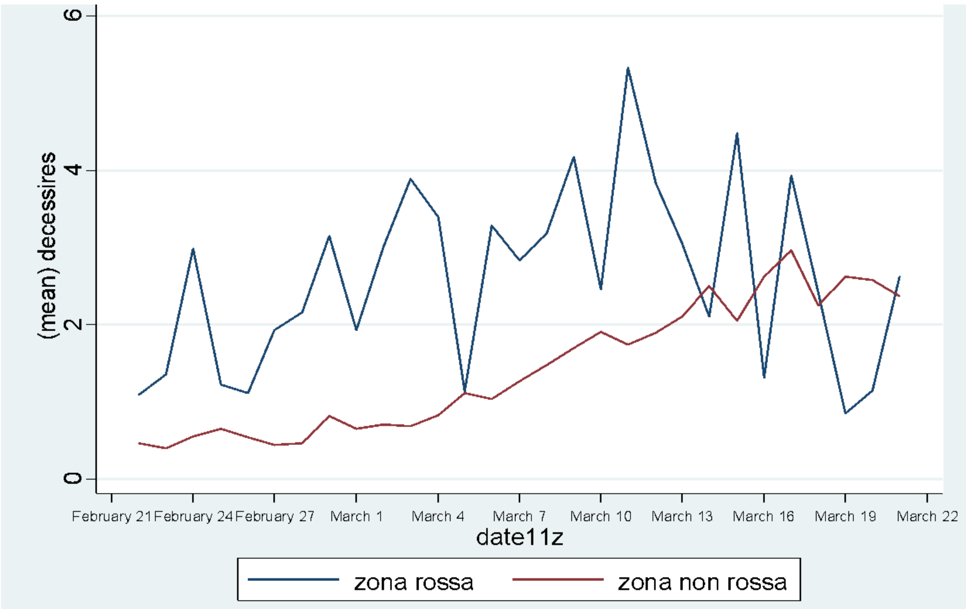
Our analysis concerns municipalities located in the the Lodi, Bergamo, Cremona provinces: in particular we use data on overall mortality from February 22nd until March 20th 2020, not those on Covid-19 related deaths for the reasons explained above, i.e. to dodge the well-known diatribe between deaths due to Covid-19 and deaths with Covid-19.

Furthermore, it has to be made crystal clear that that some of those towns were included in the Red Zone while others were not. Mortality in municipalities included in the Red Zone has been found lower with respect to that in municipalities in the same or bordering provinces which were not included in the Red Zone, i.e. where a decision to curb contagions and deaths was not quickly taken.

We start off from a common trend hypothesis between means in overall deaths (per 10,000 inhabitants) in the Red Zone municipalities and in the adjacent towns belonging to the Bergamo, Lodi, Cremona provinces for which daily availability is warranted.

Figure 2 shows a parallel trend with an inversion for the Red Zone starting from March 12th 2020. For this reason, in our chosen technique we have decided a cut off date of March 8th between the time before and after the intervention. Nevertheless, we try to use also March 12th as a threshold date. As can be seen from figure 2, the latter date seems the one from when the trend starts reversing. This is not surprising as Covid-19 related deaths are usually quite persistent in time and only slowly decay. In other words, lockdowns are likely to have quite immediate reducing effects on contagions but not on deaths.

Figure 2 – *Deaths in the delimited red zone and outside the red zone.*



Source: Authors' elaborations on ISTAT data.

By exploiting the time lag in municipalities included in the Red Zone since February 21st, we are able to verify that after March 12th [3] mortality in the so called "treated" municipalities (included in the circumscribed Red Zone) and "controls" (those which were not treated i.e. not included in the same Red Zone) is absolutely different.

To gauge this, we make use of diff-in-diff methodology used to estimate the treatment effect (the introduction of the delimited Red Zone) on the treated group. In our case the treated group is composed by the following ten municipalities (with population at the right): Codogno 15,422; Castiglione d'Adda 4,612;

[3] The end of the circumscribed Red Zone was decided on March 8th but some days are need to record fatalities.

Casalpusterlengo 15,118; Fombio 2,307; Maleo 3,037; Somaglia 3,827; Bertonico 1,071; Terranova dei Passerini 903; Castelgerundo 1,476; San Fiorano 1,848.

The Difference-in-difference method allows estimating causal effects based on external policy changes. This method captures the significant differences in outcomes across the treatment and control groups, which occur before and after an intervention. There are two reasons for including covariates in a difference in differences regression: to identificate the treatment effect and to reduce the error variance (i.e. increase power of statistical tests). The number of families could affect the dependent variable but would not affect the policy effect on the dependent variable.

In the equation the dependent variable is deaths/residents, the treatment variable is red zone/no red zone, the covariate is the number of families. In other words the approach we have chosen takes the following form:

$$d_{it} = R_{it} + f_{it} + \varepsilon_{it} \tag{1}$$

Where d is the number of deaths over resident inhabitants in the i-th municipality, R is the red zone /no red zone dummy, f is the number of families in the same municipality, ε is the error term, t is the time-subscript. This variable is a signal of a "same-dwelling density" which could worsen early spread of a disease and thus increase correlated hospitalizations and deaths. Afterwards, we augment (1) with other covariates as a robustness check so that it becomes:

$$d_{it} = R_{it} + X_{it} + \varepsilon_{it} \tag{2}$$

In the X vector in (2) we include the number of people attending Academic courses by municipality of residence and the mean income of that municipality to capture the effects of education and in come on engagement towards public health. Data for these covariates are obtained from the Atlas of Italian Municipalities and refer to the latest available year (2017) for people attending higher education courses, and to December 2019 (i.e. two months before the pandemic outbreak) for the other[4].

4. Results

Table 1 shows that the establishment of the circumscribed Red Zone has determined a reduction in mortality of 0.96 people per 10,000 inhabitants from March 8th through March 22nd 2020 (about 128 fewer deaths at the March 8th cut off). Thus, in the very short term, the institution of this containment zone has been useful

[4] We also used another variable to account for the older mean age computed by muncipality in Lombardy at the end of 2019. This variable could help a researcher account for the effect of the spread of a respiratory diseases among the an older population.

to avoid an uncontrolled spread of the most dangerous strain of Covid with a very likely, connected increase in deaths.

Table 1 – *Diff in diff estimation results with March 8th cut off.*

Number of observations in the DIFF-IN-DIFF: 3859

	Before	After	
Control:	1710	1999	3709
Treated:	73	77	150
	1783	2076	

Bootstrapped Standard Errors

Outcome var.	deces~s	S. Err.	|t|	P>|t|
Before				
Control	0.712			
Treated	2.422			
Diff (T-C)	1.710	0.305	5.61	0.000***
After				
Control	2.215			
Treated	2.966			
Diff (T-C)	0.751	0.354	2.12	0.034**
Diff-in-Diff	-0.959	0.481	1.99	0.046**

R-square: 0.13
* Means and Standard Errors are estimated by linear regressic
**Inference: *** p<0.01; ** p<0.05; * p<0.1

Source: our calculations from ISTAT data.

Secondly we insert the number of households resident in those municipalities among the covariates. As can be seen, estimates do not exhibit virtually any change (a reduction of 0.95 deaths per 10,000 inhabitants) with the usual March 8th cut off.

Table 2 – *Diff in diff estimation results with March 8th cut off controlling for the number of households.*

Number of observations in the DIFF-IN-DIFF: 3859

	Before	After	
Control:	1710	1999	3709
Treated:	73	77	150
	1783	2076	

Bootstrapped Standard Errors

Outcome var.	deces~s	S. Err.	|t|	P>|t|
Before				
Control	0.807			
Treated	2.489			
Diff (T-C)	1.681	0.304	5.53	0.000***
After				
Control	2.301			
Treated	3.030			
Diff (T-C)	0.729	0.293	2.48	0.013**
Diff-in-Diff	-0.952	0.417	2.28	0.022**

R-square: 0.13
* Means and Standard Errors are estimated by linear regression
**Inference: *** p<0.01; ** p<0.05; * p<0.1

Source: our calculations from ISTAT data.

Table 3 shows that reduction in overall deaths is about 1.5 per 10,000 inhabitants when the other cut off date (March 12th) is chosen.

Table 3 – *Diff in diff estimation results with March 12th cut off.*

```
Number of observations in the DIFF-IN-DIFF: 3859
          Before          After
   Control: 2248          1461          3709
   Treated: 95            55            150
            2343          1516
Bootstrapped Standard Errors
```

Outcome var.	deces~s	S. Err.	|t|	P>|t|
Before				
Control	0.951			
Treated	2.722			
Diff (T-C)	1.771	0.264	6.72	0.000***
After				
Control	2.400			
Treated	2.664			
Diff (T-C)	0.264	0.419	0.63	0.529
Diff-in-Diff	-1.507	0.491	3.07	0.002***

```
R-square:    0.11
* Means and Standard Errors are estimated by linear regression
**Inference: *** p<0.01; ** p<0.05; * p<0.1
```

Source: our calculations from ISTAT data.

Table 4 shows that the results do not vary when the first covariate (number of families) is included.

Table 4 - *Diff in diff estimation results with March 12th cut off controlling for the number of households.*

```
Number of observations in the DIFF-IN-DIFF: 3859
          Before          After
   Control: 2248          1461          3709
   Treated: 95            55            150
            2343          1516
Bootstrapped Standard Errors
```

Outcome var.	deces~s	S. Err.	|t|	P>|t|
Before				
Control	1.046			
Treated	2.790			
Diff (T-C)	1.743	0.249	6.99	0.000***
After				
Control	2.486			
Treated	2.729			
Diff (T-C)	0.243	0.415	0.59	0.558
Diff-in-Diff	-1.500	0.496	3.02	0.003***

```
R-square:    0.12
* Means and Standard Errors are estimated by linear regression
**Inference: *** p<0.01; ** p<0.05; * p<0.1
```

Source: our calculations from ISTAT data.

4.1 Robustness check: more than one covariate

Table 5 below shows that the inclusion of two other covariates (education and income) for the March 8th threshold does not change our results: the reduction in deaths of 0.96 per 10,000 resident people is confirmed in the very short run.

Table 5 – *Diff in diff estimation results with March 8th cut off controlling for the number of households, education being attended, income.*

Number of observations in the DIFF-IN-DIFF: 3859

	Before	After	
Control:	1710	1999	3709
Treated:	73	77	150
	1783	2076	

Bootstrapped Standard Errors

Outcome var.	deces~s	S. Err.	|t|	P>|t|
Before				
Control	1.417			
Treated	3.057			
Diff (T-C)	1.640	0.273	6.01	0.000***
After				
Control	2.906			
Treated	3.590			
Diff (T-C)	0.684	0.359	1.91	0.057*
Diff-in-Diff	-0.956	0.425	2.25	0.025**

R-square: 0.15
* Means and Standard Errors are estimated by linear regression
**Inference: *** p<0.01; ** p<0.05; * p<0.1

Source: our calculations from ISTAT data.

The same applies when the threshold is shifted to March 12th as can be seen in table 6: the reduction in deaths is always -1.5 per 10,000 inhabitants.

Table 6 – *Diff in diff estimation results with March 12th cut off controlling for the number of households, education being attended, income.*

Number of observations in the DIFF-IN-DIFF: 3859

	Before	After	
Control:	2248	1461	3709
Treated:	95	55	150
	2343	1516	

Bootstrapped Standard Errors

Outcome var.	deces~s	S. Err.	|t|	P>|t|
Before				
Control	1.649			
Treated	3.351			
Diff (T-C)	1.702	0.274	6.21	0.000***
After				
Control	3.085			
Treated	3.282			
Diff (T-C)	0.198	0.425	0.46	0.642
Diff-in-Diff	-1.505	0.495	3.04	0.002***

R-square: 0.13
* Means and Standard Errors are estimated by linear regression
**Inference: *** p<0.01; ** p<0.05; * p<0.1

Source: our calculations from ISTAT data.

Finally, results for the municipal mean age are not statistically significant[5]. This is a sign that at the onset of the pandemic in Northern Italy, the differences among mean ages in Lombardy's municipalities were too small to help account for the change in the relative number of deaths.

Conclusions

Our results explain that establishing a Red Zone has been effective in reducing deaths in the very short term as it helped reducing pressures on health facilities which were not used to cope with this type of disease during the first "Wuhan" wave. On the other hand, municipalities bordering those included in the Red Zone have experienced a higher number of average deaths per number of residents. This result is confirmed when one or more covariates (number of households, education, income) are included, while the mean age is not statistically significant, suggesting that the differences among mean ages between municipalities were (and still are) too small to account for the change in the relative number of deaths. This can Of course, we are very well aware that early lockdowns (or Red Zones) are much more effective than hard lockdowns (see for example Plümper and Neumayer, 2022)

Even though, results suggest that delimited lockdowns can be effective in reducing spreads of dangerous diseases, these are kind of interventions which cannot be kept indefinitely of course. Furthermore, in the longer term, less restrictive and more voluntary measures could even be more effective due to individual self-learning and more responsible behavior (see Bendavid et al., 2021).

To put it more clearly, struggles against highly transmissible airborne viruses are not 100 meter races but rather marathons: effective short-term measures which clearly lower deaths should be coupled with longer-term decisions where individual choices have to be led and respected at the same time.

The debate between preserving individual choices from one hand and safeguarding minimal, sufficient conditions in public health is thorny to say the least. While our paper is focused only on evaluating the effectiveness of short-term measures (the only ones virtually available almost all over Europe in February and March 2020) in terms of reducing deaths, we are well aware that the longer the time passed the higher will be the relevance of preserving individual, ever more informed choices compared to public health needs.

[5] They are available upon request.

References

BENDAVID E., OH C., BHATTACHARYA J., IOANNIDIS J.P.A. 2021. Assessing mandatory stay-at-home and business closure effects on the spread of COVID-19. European Journal of Clinical Investigation. Volume 51, Issue 4. April. https://doi.org/10.1111/eci.13484.

BRAUNER J.M., MINDERMANN S., SHARMA M., ET AL. 2020. Inferring the effectiveness of government interventions against COVID-19. Science. Vol. 371 Issue 6531. December 15^{th}. https://doi.org/110.1126/science.abd9338.

CHIRICO F., NUCERA G., SZARPAK L. 2021. COVID-19 mortality in Italy: The first wave was more severe and deadly, but only in Lombardy region. Journal of Infection. Volume 83, Issue 1, E16, July 01. DOI: https://doi.org/10.1016/j.jinf.2021.05.006.

FIOR M., MPAMPATSIKOS V. 2021. COVID-19 and estimates of actual deaths in Italy. Scenarios for urban planning in Lombardy. Journal of Urban Management. Volume 10, Issue 3, September, Pages 275-301.

HAUG N., GEYRHOFER L., LONDEI A. ET AL. 2020. Ranking the effectiveness of worldwide COVID-19 government interventions. Nat Hum Behav 4, 1303–1312. https://doi.org/10.1038/s41562-020-01009-0.

HONG S-H., HWANG H., PARK M-H. 2021. Effect of COVID-19 Non-Pharmaceutical Interventions and the Implications for Human Rights. International Journal of Environmental Research and Public Health; 18(1):217. https://doi.org/10.3390/ijerph18010217.

LIU Y., MORGENSTERN C., KELLY J. ET AL. 2021. The impact of non-pharmaceutical interventions on SARS-CoV-2 transmission across 130 countries and territories. BMC Med 19, 40. https://doi.org/10.1186/s12916-020-01872-8.

MENDEZ-BRITO A., EL BCHERAOUI C., POZO-MARTÍN F. 2021. Systematic Review of Empirical Studies Comparing the Effectiveness of Non-Pharmaceutical Interventions Against Covid-19. Journal of Infection, Volume 83, Issue 3, September 2021, Pages 281-293.

PLÜMPER T., NEUMAYER E. 2022. Lockdown policies and the dynamics of the first wave of the Sars-CoV-2 pandemic in Europe, Journal of European Public Policy, 29:3, 321-341.https://doi.org/110.1080/13501763.2020.1847170.

YACONG B., CUI G., CHANGQING L., YIQIAN Z, HAO B-L., YUMIAO Z., MD SHAKHAOAT H., CHAN J.W.M., YEUNG D. W., KWOK K-O., WONG S.Y.S., LAU A.K.H., XIANG QIAN L. 2021. Effectiveness of non-pharmaceutical interventions on COVID-19 transmission in 190 countries from 23 January to 13 April 2020, International Journal of Infectious Diseases, Volume 102, Pages 247-253, ISSN 1201-9712, https://doi.org/10.1016/j.ijid.2020.10.066.

SHARMA M., MINDERMANN S., ROGERS-SMITH C. ET AL. 2021. Understanding the effectiveness of government interventions against the resurgence of COVID-19 in Europe. Nat Commun 12, 5820. https://doi.org/10.1038/s41467-021-26013-4.

SUMMARY

The analysis based on diff in diff method concerns municipalities of the Lodi, Bergamo, Cremona provinces: in particular, we use data on overall mortality, not those on Covid-19 related deaths.

We start off from a common trend hypothesis between means in overall deaths (per 10,000 inhabitants) in the Red Zone municipalities and in the adjacent towns belonging to the Bergamo, Lodi, Cremona provinces for which daily availability is warranted.

Our results explain that establishing a Red Zone has been effective in reducing deaths in the very short term as it helped reducing pressures on health facilities which were not used to cope with this type of disease during the first "Wuhan" wave.

Marco BIAGETTI, INAPP, m.biagetti@inapp.org
Valentina FERRI, INAPP, v.ferri@inapp.org