The Grey Zone

How Not Imposing a Strict Lockdown at the Beginning of a Pandemic Can Cost Many Lives

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Barcelona, August 28 2023

The Grey Zone

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On February 23 2020, the Italian government ordered its military police to seal the borders and declared a Red Zone around 10 municipalities of the province of Lodi in the Lombardy Region.

The Grey Zone

On the same day, a patient tested positive at the hospital of Alzano Lombardo, a town in the Serio Valley, Bergamo, 60 miles away from Lodi.

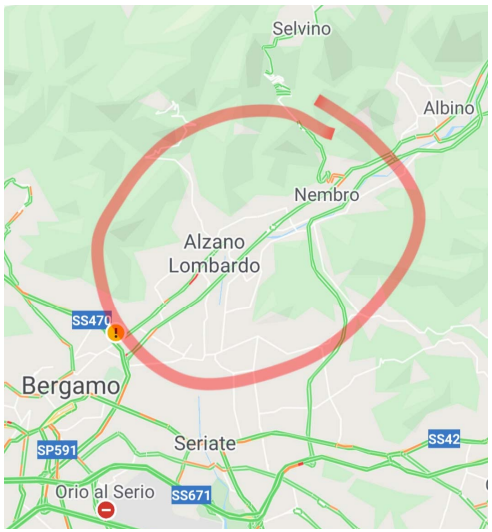
On February 28, the province of Bergamo reported 103 positive Covid-19 cases. The government's scientific committee did not advise in favor of a Red Zone nor did Lombardy health officials.

Confindustria Bergamo, the province industrial association, posted a video titled "Bergamo is running" .

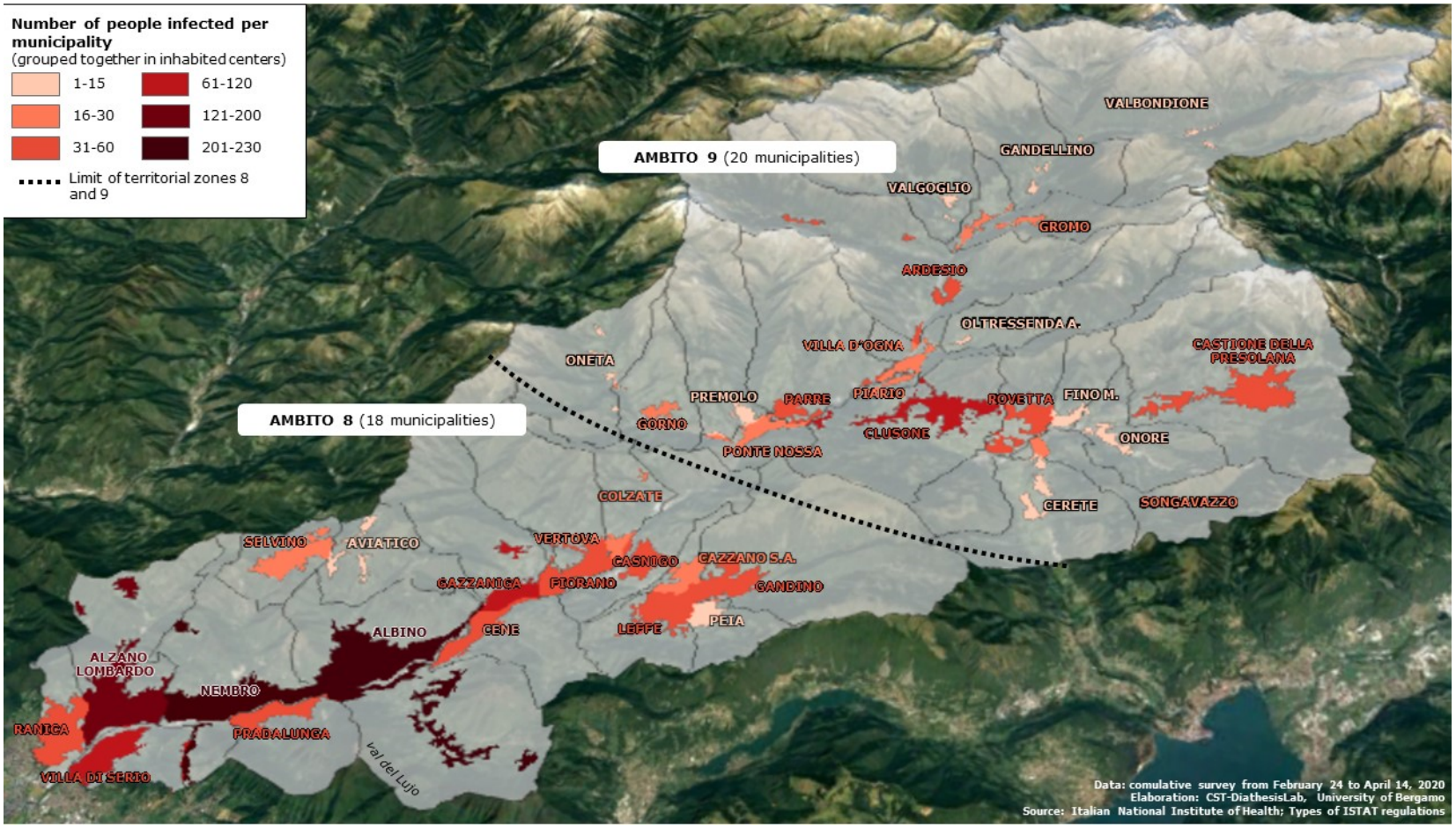
The Grey Zone

On March 3, the government's scientific committee proposed a Red Zone in the Serio Valley around Nembro and Alzano Lombardo.

On March 4, the military police was ready to seal the borders and turn the area into a Red Zone. But nothing happened. No Red Zone was ever declared.

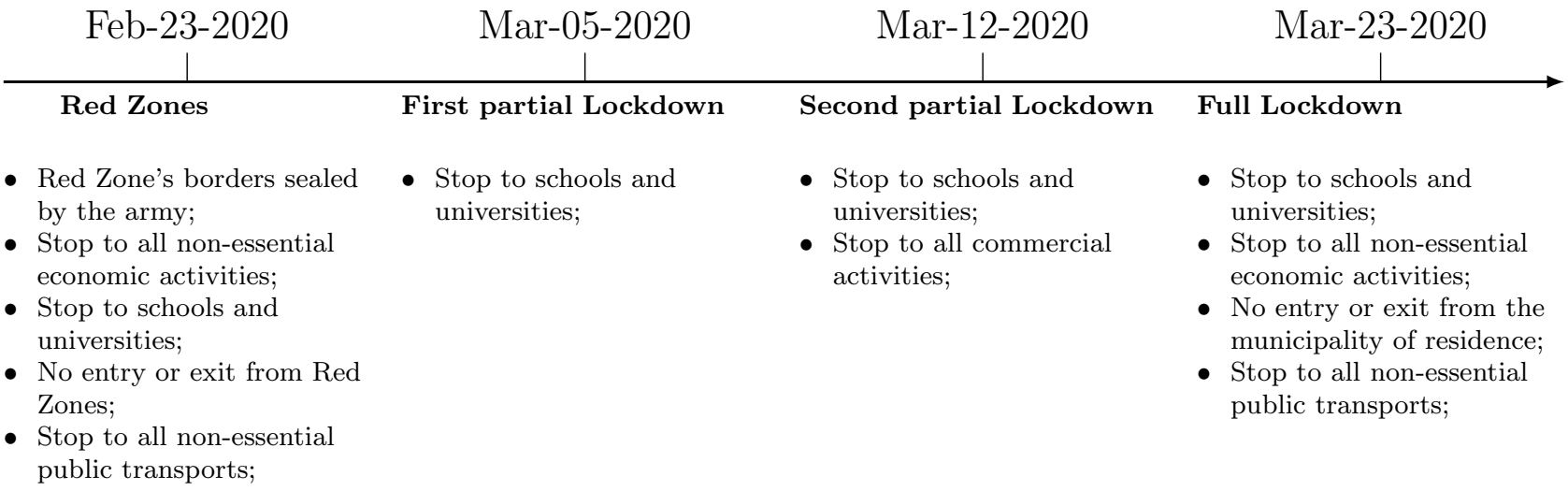


The Serio Valley



The Grey Zone

Timeline of public policy measures adopted to contain the first wave of the pandemic.



Research Question

Would imposing a Red Zone in the Serio Valley have helped saving lives?

The paper in a nutshell

We estimate the causal effect of the (missed) adoption of a Red Zone in this area on daily excess mortality in 2020.

- We apply the Synthetic Control Methods (SCM) to a panel data at the municipality and daily level.
- We find that about two-thirds of the reported deaths could have been avoided had the government declared a Red Zone.
- We find similar results using the Augmented SCM and the Synthetic DiD.
- We show that, SCM, DiD, and similar methods implicitly restrict effect heterogeneity on the effect of the pandemic.
- We provide a way to empirically assess the credibility of this assumption in our setting.

Literature

In the absence of mass screening and aggressive contact tracing, the timely set up of a Red Zone has been recognized as one of the most effective Non Pharmaceutical Interventions (NPIs) (Acemoglu et al., 2021; Chernozhukov et al., 2021; Fagiuoli et al., 2020; Signorelli et al., 2020).

Previous studies using counterfactual analysis have shown that strict initial lockdown measures played an important role in limiting the spread of Covid-19 (Cerqueti et al., 2022; Chernozhukov et al., 2021; Cho, 2020; Fang et al., 2020; Flaxman, Mishra, Gandy et al., 2020).

Singh et al. (2021) suggest that the actual impact of NPI measures may depend on the characteristics of the groups that receive the treatment and ultimately on their compliance.

Identification strategy

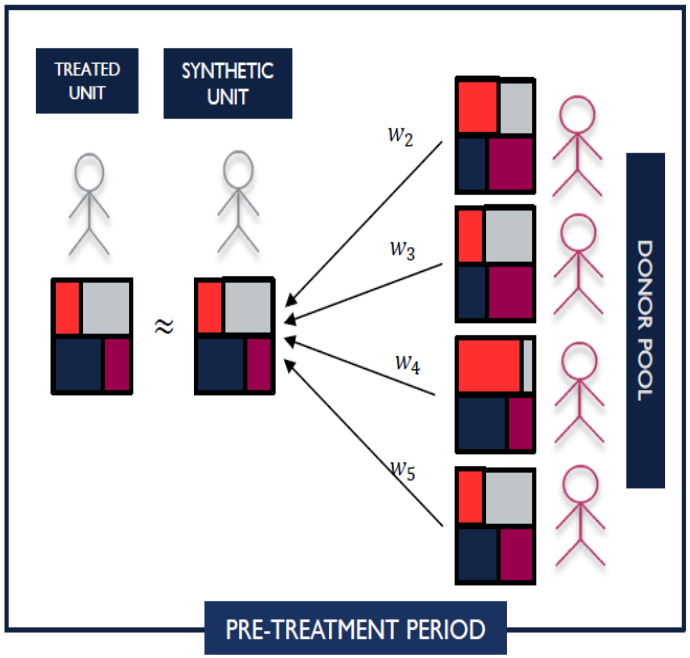
Synthetic Control Method (Abadie et al. 2003 and later)

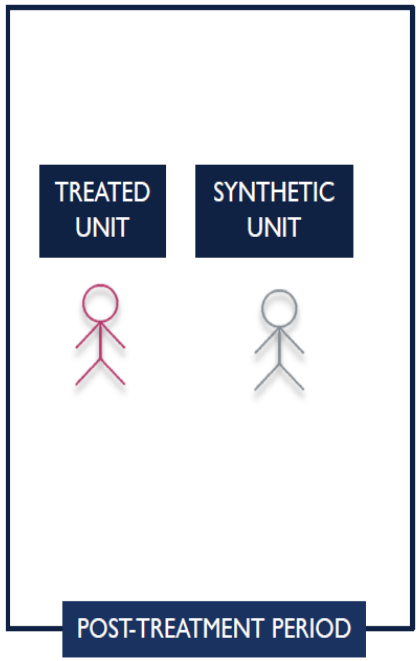
Idea: create a linear combination of control units that mimics what would have happened to the treated units in the absence of the intervention.

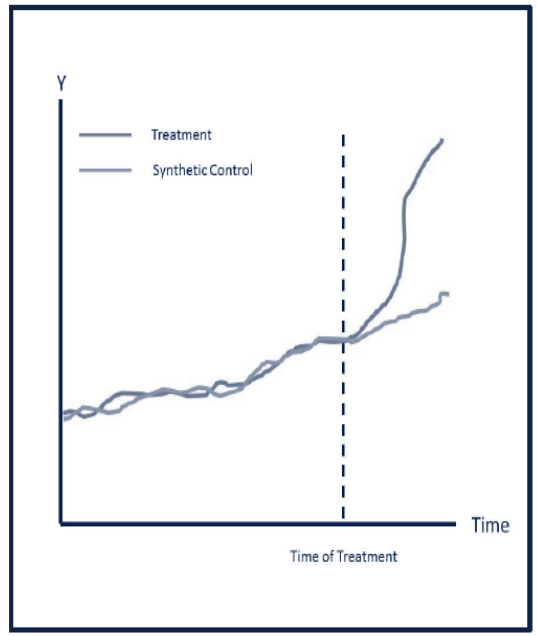
Weights: chosen to minimize the distance in the pre-intervention characteristics of the treated and of the synthetic control.

Causal effect: estimated as the difference between the observed outcome of the treated and of the synthetic control units in the post-intervention period.

Graphical illustration







Notation

We assume that

$$Y_{jt}^{NP} = f_{jt} \text{ (no pandemic)},$$

$$Y_{jt}^{RZ} = \underbrace{\beta_{jt}}_{\textit{Effect of the pandemic with RZ}} + f_{jt} = \beta_{jt} + Y_{jt}^{NP} \text{ (Red Zone)},$$

$$Y_{jt}^{NRZ} = \beta_{jt} + \underbrace{\gamma_{jt}}_{\textit{Effect of not imposing a RZ}} + f_{jt} = \gamma_{jt} + Y_{jt}^{RZ} \text{ (no Red Zone)},$$

where f_{jt} are unobserved common components that determine the outcome Y.

Implicit additional assumption

- Let unit 1 be one of the treated municipalities and units from 2 to J be municipalities that imposed a Red Zone.
- The effect of no implementing a red zone γ_{1t}, we need that the SCM weights satisfy $\sum_{j=2}^{J} \hat{w}_j f_{jt} = f_{1t} + o_p(1)$ as usual.
- In addition we need to assume that

$$\sum_{j=2}^{J} \hat{w}_j \beta_{jt} = \beta_{1t} \text{ non-extreme pandemic effect (NEPE).}$$

Plausibility of NEPE

- We are able to control for many geographic, and socio-demographic characteristics that are believed to be the main determinants for the spread of the virus.
- All municipalities (except Vo' Euganeo) are in the same region.
- Thus, we expect NEPE to be reasonably plausible.
- We use municipalities that were not immediately hit by the pandemic to further check the plausibility of NEPE.

Using non-affected municipalities

We can recover the total effect of the pandemic on our treated unit and on the Red Zone units (that received a positive weight) as

$$\gamma_{1t} + \beta_{1t} \approx \widehat{\gamma_{1t} + \beta_{1t}} = Y_{1t} - \sum_{i=J+1}^{K} \hat{w}_i Y_{it}.$$

$$\beta_{jt} \approx \hat{\beta}_{jt} = Y_{jt} - \sum_{i=J+1}^{K} \tilde{w}_i^j Y_{it}, \quad j = 2, \ldots, J,$$

Plausibility of NEPE

We can then estimate γ_{1t} as

$$\tilde{\gamma}_{1t} = \widehat{\gamma_{1t} + \beta_{1t}} - \max_{j \in [2,\ldots,J], \hat{w}_j > 0} \hat{\beta}_{jt}$$

$$= \underbrace{\left(Y_{1t} - \sum_{i=J+1}^{K} \hat{w}_i Y_{it} \right)}_{\widehat{\gamma_{1t}+\beta_{1t}}} - \max_{j \in [2,\ldots,J], \hat{w}_j > 0} \underbrace{\left(Y_{jt} - \sum_{i=J+1}^{K} \tilde{w}_i^j Y_{it} \right)}_{\hat{\beta}_{jt}}.$$

Two interpretations of the quantity $\tilde{\gamma}_{1t}$:

1. If $\beta_{1t} < \max_{j \in [2,\ldots,J], \hat{w}_j > 0} \hat{\beta}_{jt}$, $\tilde{\gamma}_{1t}$ is a lower bound for γ_{1t}.
2. If $\beta_{1t} > \max_{j \in [2,\ldots,J], \hat{w}_j > 0} \hat{\beta}_{jt}$ a large $\tilde{\gamma}_{1t}$ indicates that γ_{1t} should be large.

Using non-affected municipalities for inference

- Implementing a red zone does not completely stop the effect of the pandemic.
- Thus, we need to take into account that, in the post intervention period, the red-zone municipalities are still affected by the pandemic.
- We can use the non-affected municipalities to:
  1. Estimate the effect of the pandemic in each red-zone municipalities.
  2. As an alternative donor pool for the treated municipalities.
- The former together with our NEPE assumption allows us to estimate the effect of the pandemic the three municipalities in the Serio valley would have experienced under a red zone.
- The latter allows us to run the standard inference procedures after subtracting those effects by the respective outcomes.

Data

Data

Daily number of all-cause deaths from November 1st 2019 to October 30th 2020 on all Italian municipalities (ISTAT, Decessi anni 2011-2021).

Treatment: missed adoption of Red Zone.

Outcome variable of interest: cumulative daily excess mortality (difference between daily mortality and average mortality on the same day in the previous 8 years) at the municipality level.

Pre-treatment period: from November 1st 2019 to February 22nd 2020 (114 days).

Post-treatment period: from February 23d 2020 to October 30th 2020.

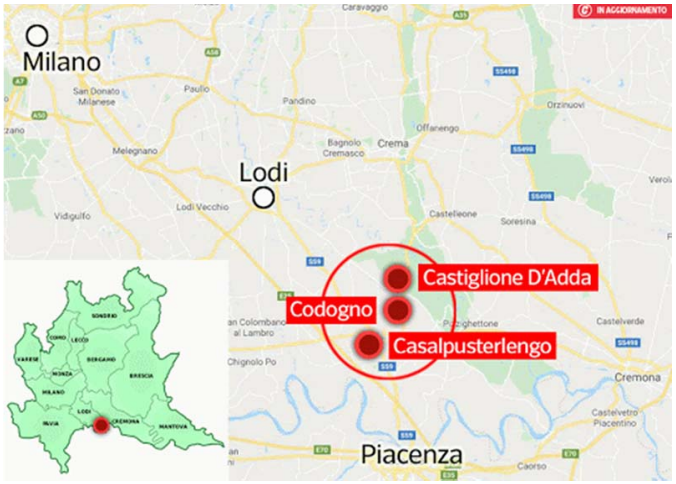
Treated units: Albino, Nembro and Alzano Lombardo in the province of Bergamo.

Data

Main donor pool: 10 municipalities in the province of Lodi, where a Red Zone was implemented from February 23 to March 23 2020, and Vo' Euganeo in the province of Padova.

Extra donor pool: 39 municipalities in Lombardy with comparable population size and with a distance from Codogno (the centre of the Red Zone) and Albino (the centre of the Serio Valley) greater than 60 km and 50 minutes drivetime.

Donor pools


Milano
Lodi
Castiglione D'Adda
Codogno
Casalpusterlengo
Piacenza
Cremona


Svizzera
Sondrio
Sondrio
Trentino-
Alto Adige
Varese
Como
Lecco
Bergamo
Gallarate
Monza
Brescia
Legnano
Milano
Veneto
Vigevano
Pavia
Lodi
Cremona
Mantova
Piemonte
Emilia-Romagna

Covariates balance: red zone

Red Zone							
Mortality, Demographic and Geographic variables	**Albino**		**Alzano Lombardo**		**Nembro**		**Average of all donors** ($n = 11$)
	Real	Synthetic	Real	Synthetic	Real	Synthetic	
-Cumulative excess mortality per 1,000 inhab.	-0.43	-0.37	-0.39	-0.34	0.23	0.25	-0.58
-PM-10 (2019)	27.99	32.61	28.12	32.69	28.12	32.65	32.51
-Share of male population (2019)	0.49	0.49	0.49	0.49	0.49	0.48	0.50
-Share of population over 65 (2019)	0.21	0.22	0.21	0.24	0.22	0.23	0.22
-Share of population over 85 (2019)	0.03	0.03	0.03	0.03	0.03	0.03	0.03
-Employees in manufacturing (2017)	2029.75	880.48	582.13	885.83	946.02	1447.79	347.06
-Attraction index (2015)	32.63	33.20	30.13	29.99	36.23	37.52	24.44
-Population density (2019)	559.58	451.34	999.90	460.65	755.77	719.39	268.45
-Altimetric area	1.00	4.67	3.00	3.99	3.00	5.00	4.82
-Distance from the closest hospital	8100.20	6996.11	0.00	5107.57	3708.14	2882.10	10264.65
-Distance from the second closest hospital	14647.63	13474.50	7087.21	12188.25	9955.18	10439.82	17305.17

Covariates balance: non-affected

Not Affected

Mortality, Demographic and Geographical variables	Albino		Alzano Lombardo		Nembro		Average of all donors ($n = 39$)
	Real	Synthetic	Real	Synthetic	Real	Synthetic	
-Cumulative excess mortality per 1,000 inhab.	-0.43	-0.40	-0.39	-0.37	0.23	0.23	0.04
-PM-10 (2019)	27.99	30.34	28.12	28.84	28.12	28.15	28.51
-Share of male population (2019)	0.49	0.50	0.49	0.50	0.49	0.49	0.49
-Share of population over 65 (2019)	0.21	0.18	0.21	0.19	0.22	0.22	0.21
-Share of population over 85 (2019)	0.03	0.02	0.03	0.02	0.03	0.03	0.03
-Employees in manufacturing (2017)	2029.75	2051.27	582.13	1521.27	946.02	1368.77	1543.44
-Attraction index (2015)	32.63	32.21	30.13	27.85	36.23	35.58	32.58
-Population density (2019)	559.58	586.70	999.90	918.37	755.77	723.96	1000.32
-Altimetric area	1.00	4.57	3.00	4.67	3.00	3.00	4.23
-Distance from the closest hospital	8100.20	7669.61	0.00	6090.03	3708.14	3394.06	6919.05
-Distance from the second closest hospital	14647.63	14655.71	7087.21	10173.52	9955.18	15029.75	19787.23

Weights: red zone

	Donor pool ($n = 11$)	Albino	Alzano Lombardo	Nembro
1	Vo'	0	0.503	0.164
2	Bertonico	0	0	0
3	Casalpusterlengo	0.089	0	0
4	Castiglione d'Adda	0	0	0
5	Codogno	0.865	0.494	0.484
6	Fombio	0	0.003	0.111
7	Maleo	0	0	0
8	San Fiorano	0	0	0
9	Somaglia	0	0	0
10	Terranova dei Passerini	0	0	0.175
11	Castelgerundo	0.046	0	0.066

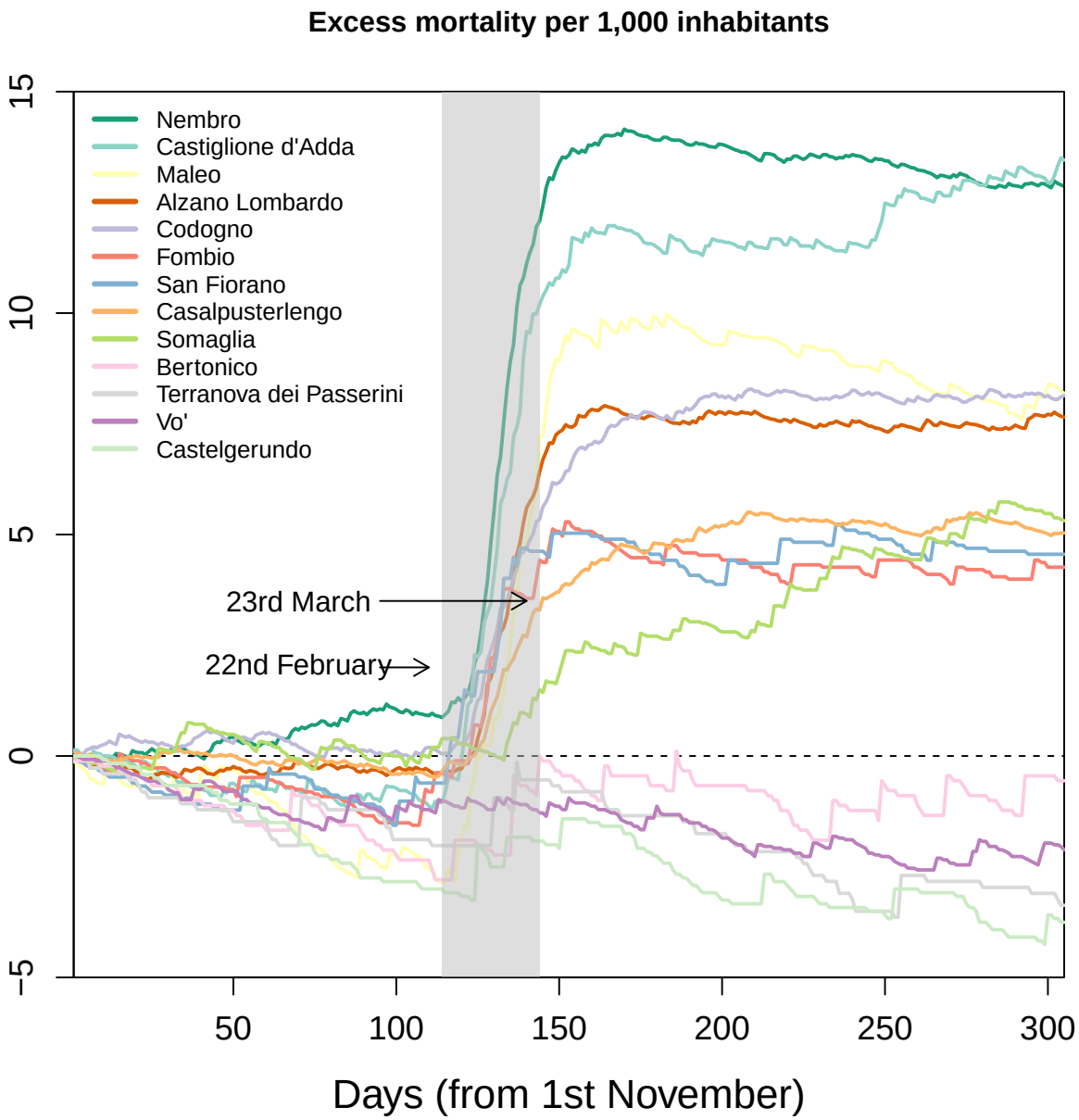
Weights: non-affected

	Donor pool ($n = 39$)	Albino	Alzano Lombardo	Nembro
1	Cardano al Campo	0.001	0	0
2	Caronno Pertusella	0	0	0
3	Castellanza	0	0	0
4	Fagnano Olona	0.001	0.524	0.044
5	Lonate Pozzolo	0.009	0	0
6	Luino	0.143	0	0
7	Malnate	0.001	0	0
8	Olgiate Olona	0.001	0	0
9	Samarate	0.11	0	0
10	Sesto Calende	0.001	0	0
11	Somma Lombardo	0	0.013	0
12	Erba	0.001	0	0
13	Olgiate Comasco	0.001	0	0.215
14	Morbegno	0	0	0
15	Arluno	0.002	0	0
16	Busto Garolfo	0.001	0	0
17	Canegrate	0.001	0	0
18	Castano Primo	0	0	0
19	Cerro Maggiore	0	0	0
20	Cesate	0.001	0	0

Weights: non-affected

21	Nerviano	0	0	0
22	Rescaldina	0.001	0	0
23	Solaro	0.049	0	0
24	Vanzaghello	0.197	0	0
25	Bedizzole	0	0	0
26	Calcinato	0	0.297	0.742
27	Carpenedolo	0	0	0
28	Gardone Val Trompia	0.23	0	0
29	Gavardo	0.24	0	0
30	Lonato del Garda	0	0.167	0
31	Sarezzo	0.002	0	0
32	Mortara	0	0	0
33	Casalmaggiore	0	0	0
34	Castel Goffredo	0	0	0
35	Curtatone	0	0	0
36	Porto Mantovano	0.001	0	0
37	San Giorgio Bigarello	0.002	0	0
38	Besana in Brianza	0.002	0	0
39	Lentate sul Seveso	0.001	0	0

Some Suggestive Trends



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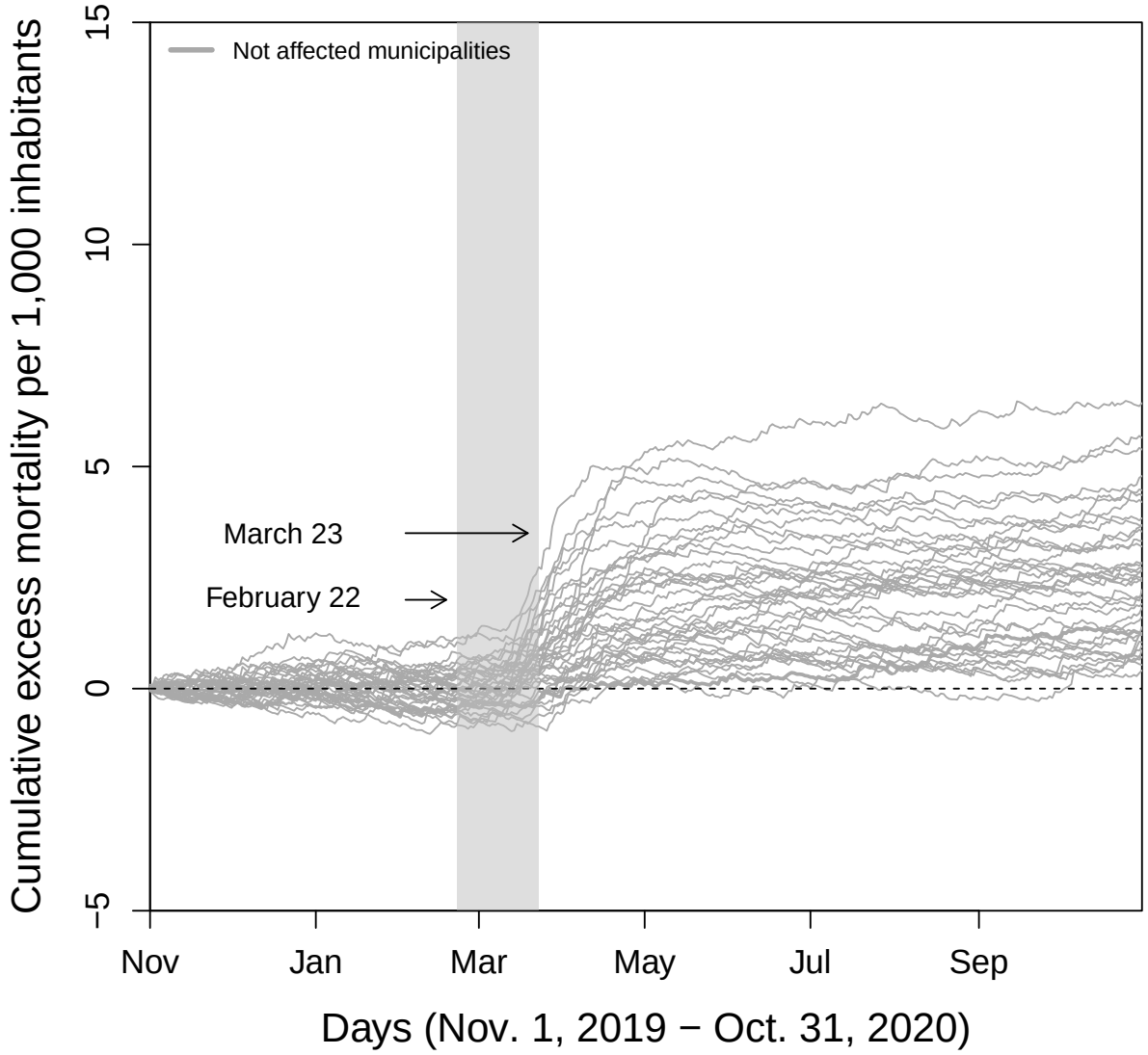
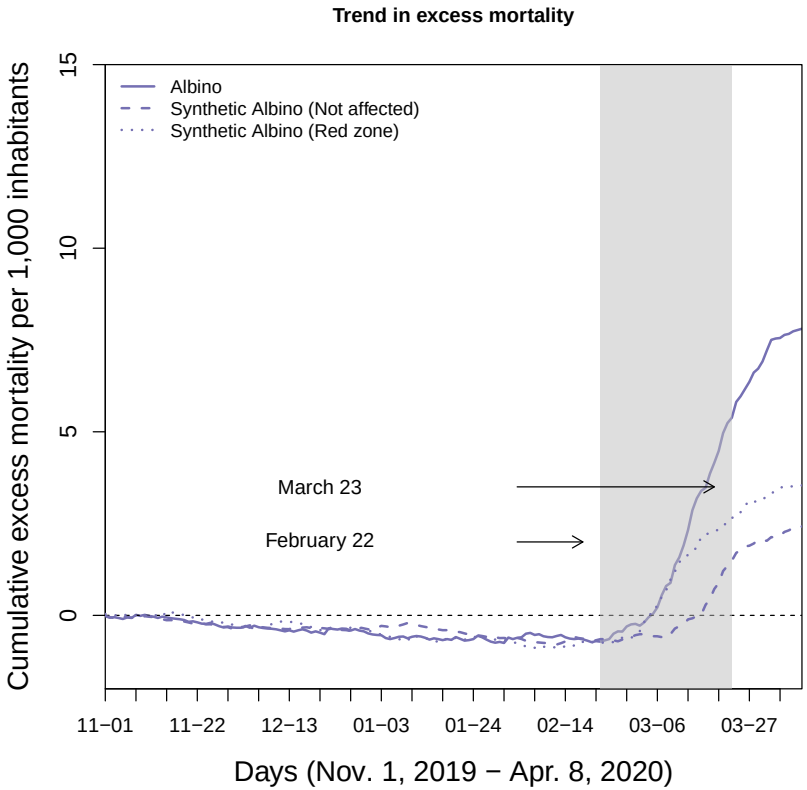
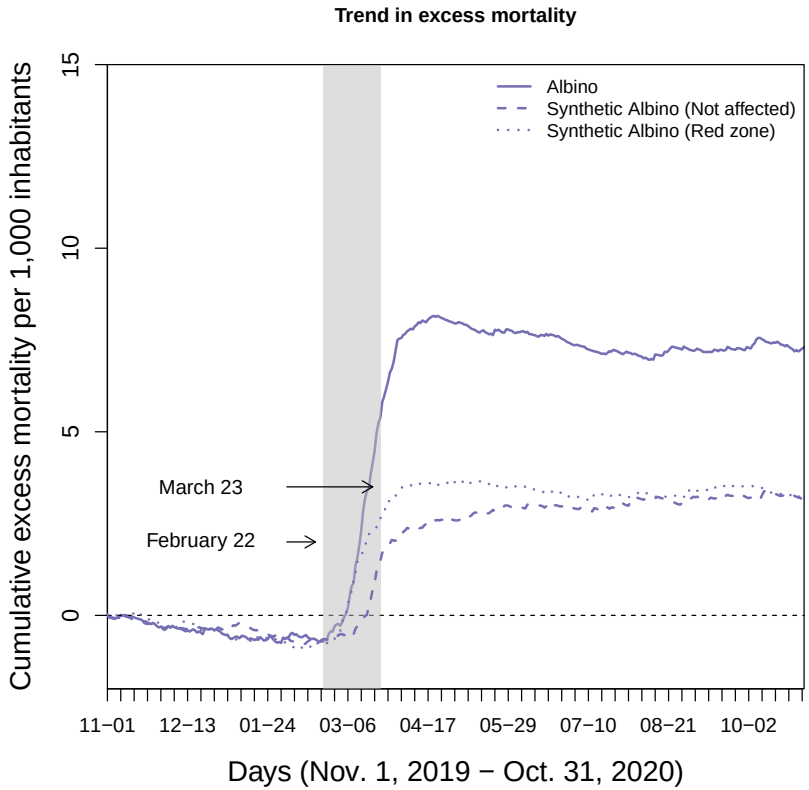


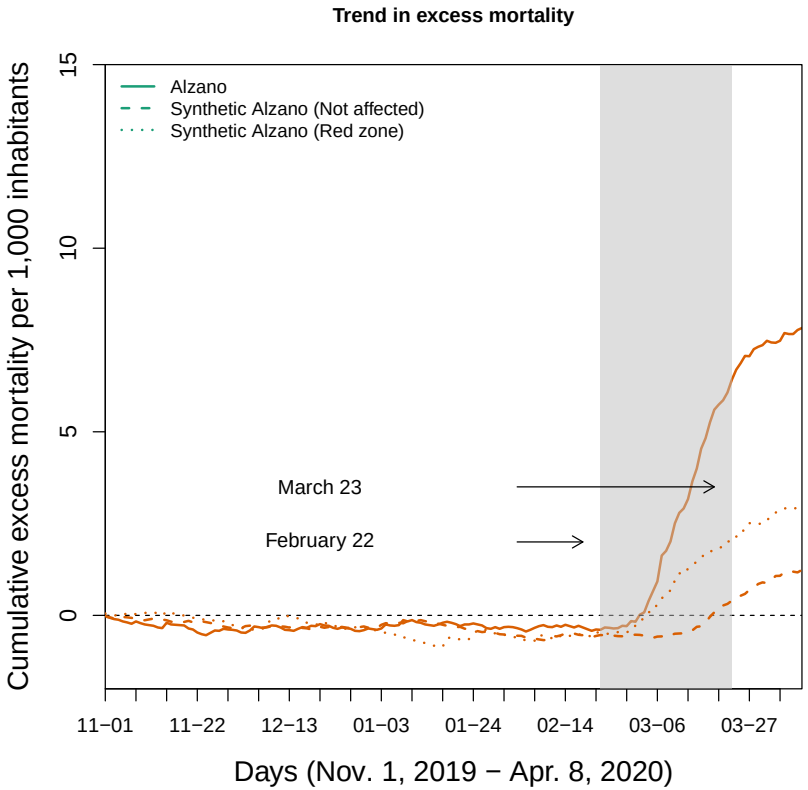
Results

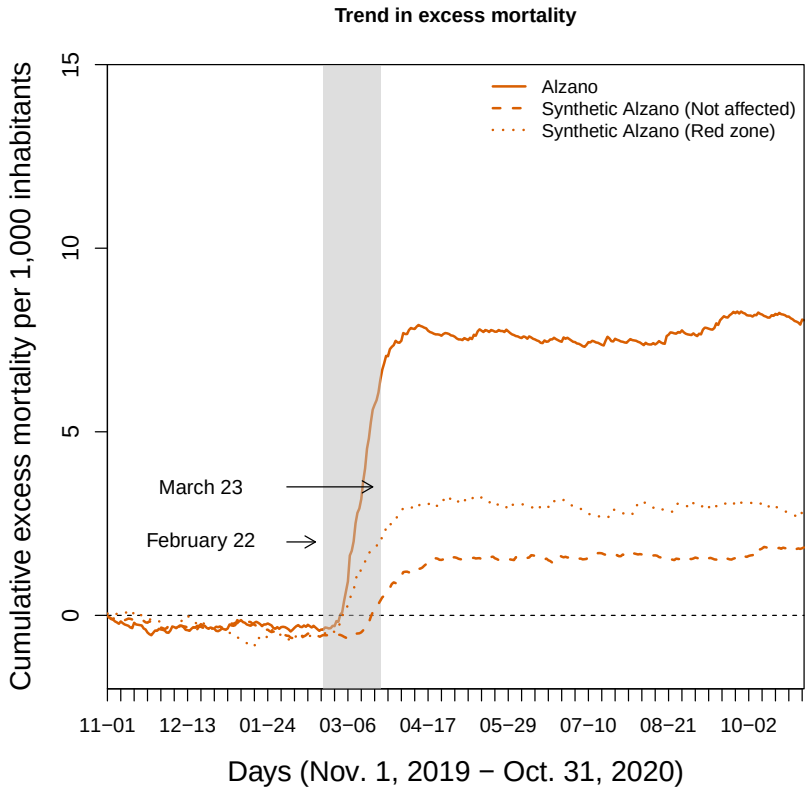
Results: Albino



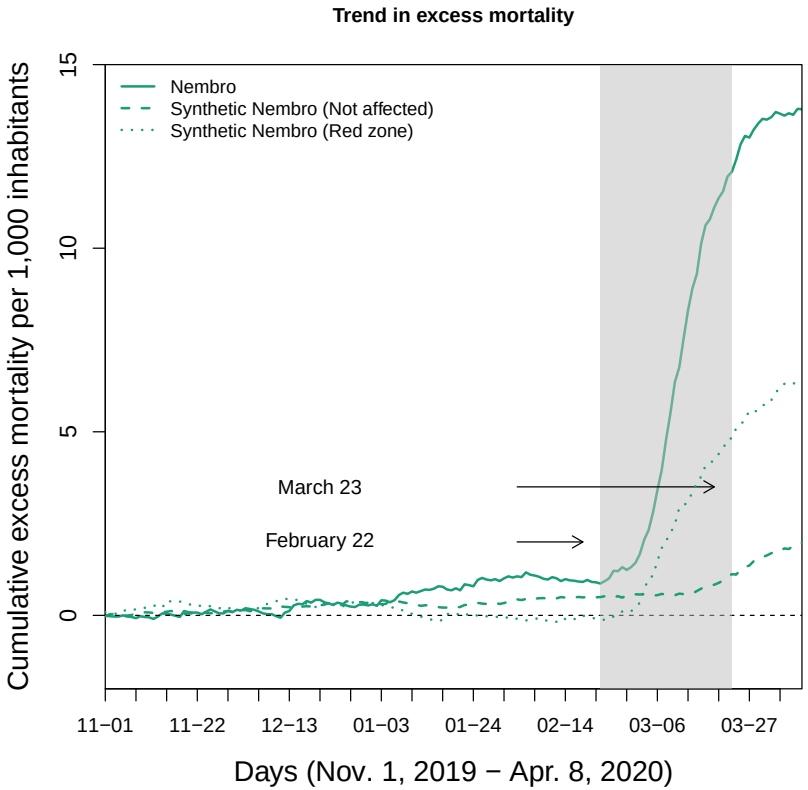


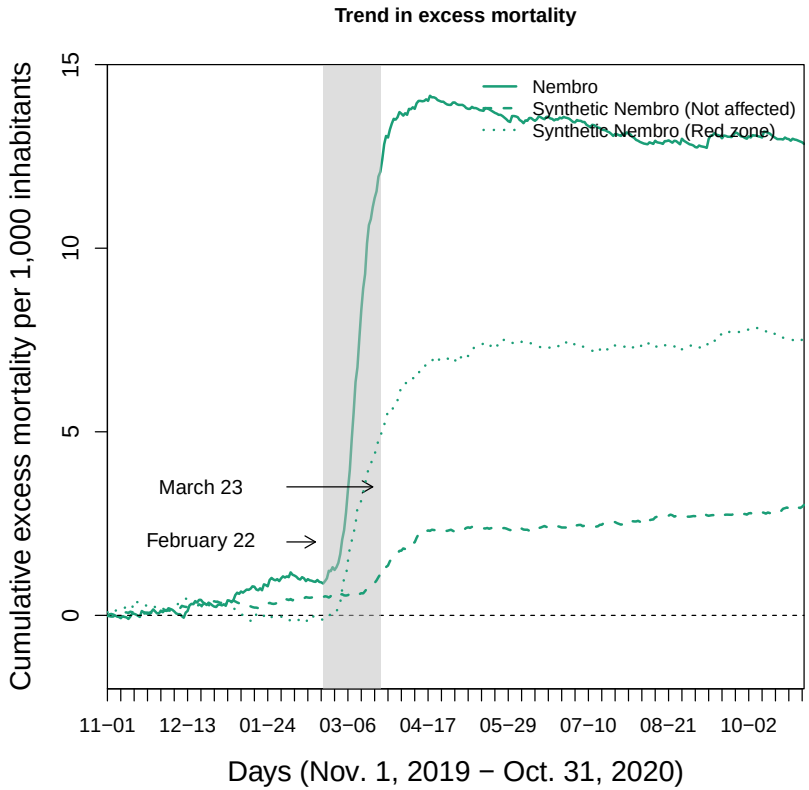
Results: Alzano Lombardo





Results: Nembro



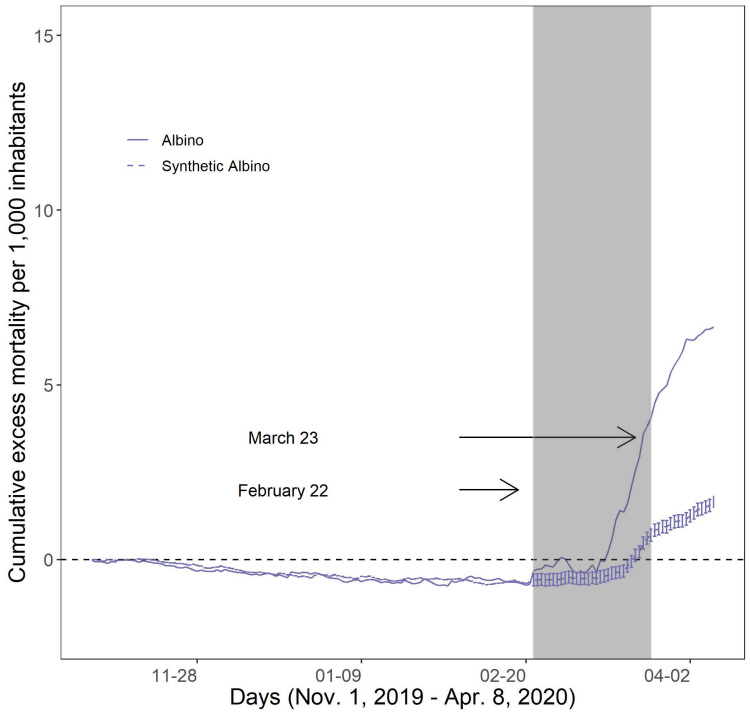


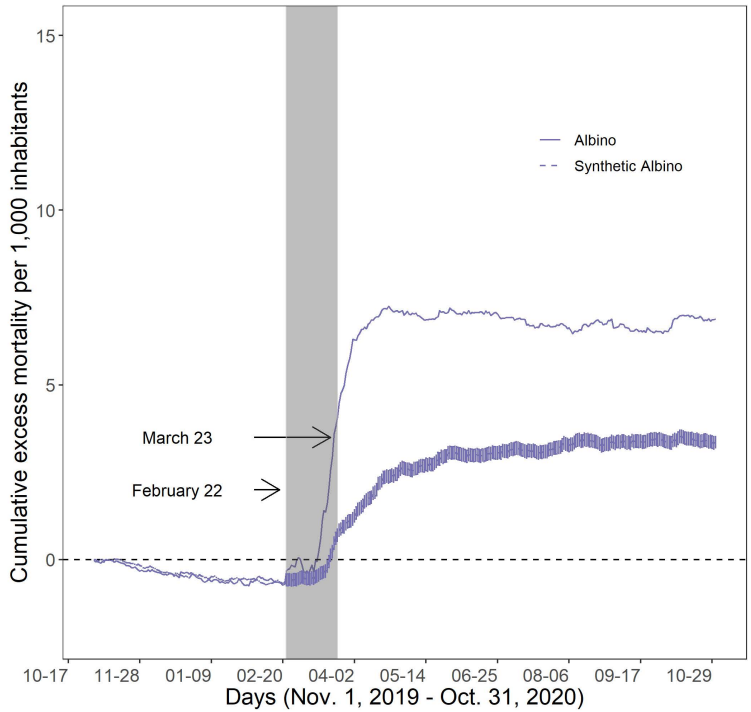
Results: treatment effects

	April 8, 2020	Max.
Albino (Red Zone)	4.27	4.61
Albino (not affected)	5.38	5.64
Alzano Lombardo (Red Zone)	4.91	5.35
Alzano Lombardo (not affected)	6.59	6.73
Nembro (Red Zone)	7.38	7.84
Nembro (not affected)	11.80	11.95

ASCM and SDiD

ASCM: Albino


Albino
Synthetic Albino
March 23
February 22
Cumulative excess mortality per 1,000 inhabitants
15
10
5
0
11-28
01-09
02-20
04-02
Days (Nov. 1, 2019 - Apr. 8, 2020)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08-06
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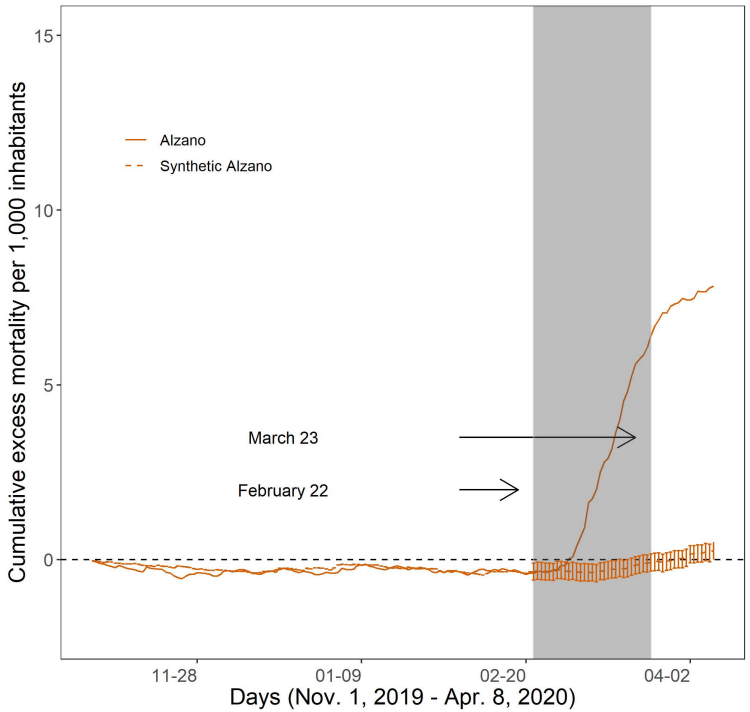
10-29
Days (Nov. 1, 2019 - Oct. 31, 2020)

ASCM: Alzano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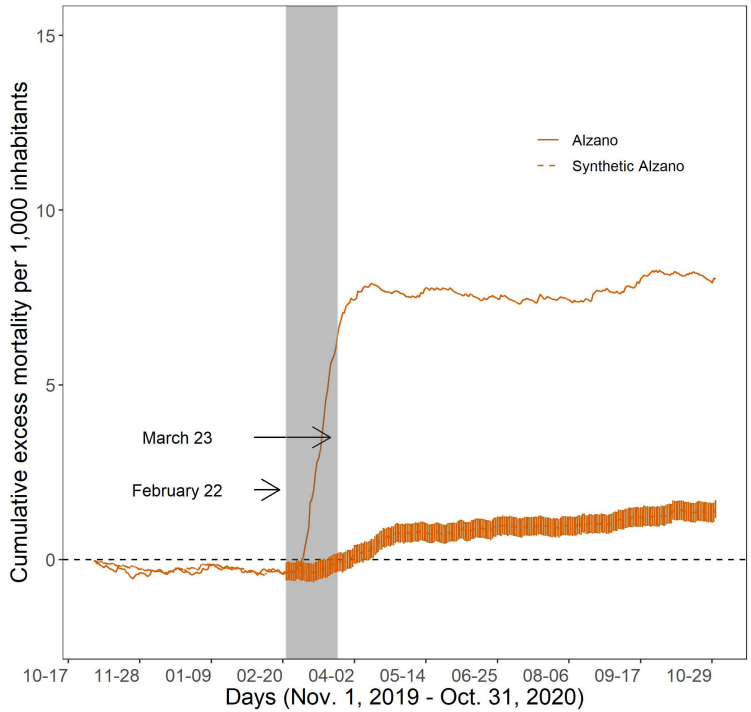
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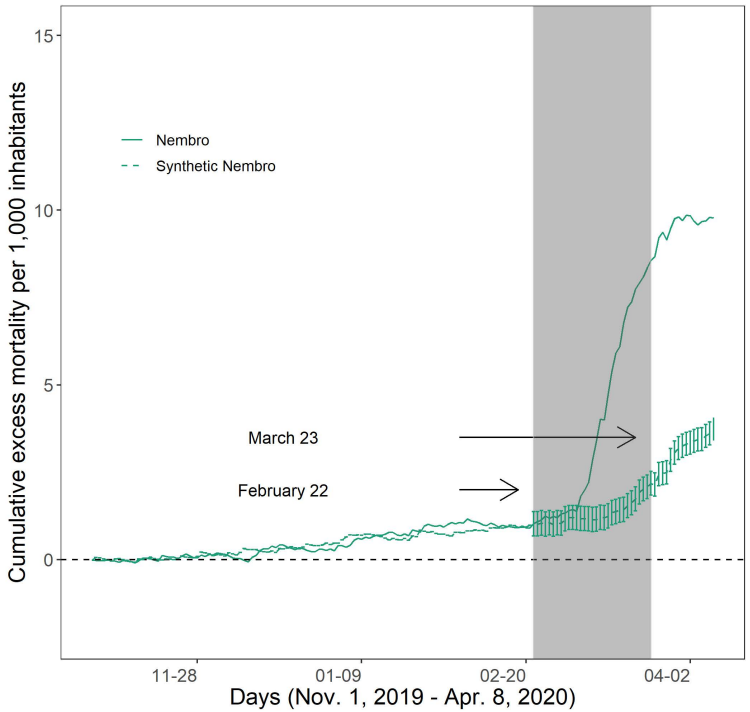
Days (Nov. 1, 2019 - Oct. 31, 2020)

ASCM: Nembro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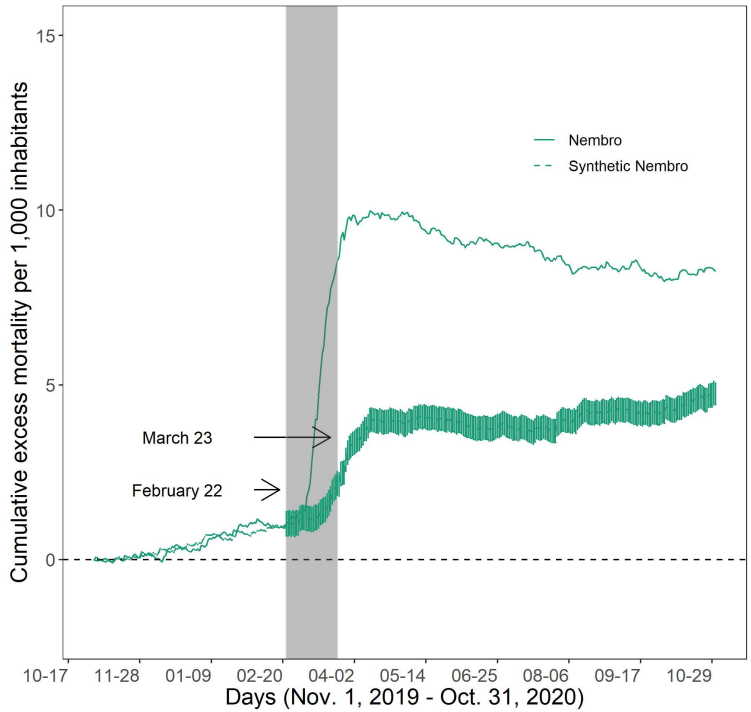
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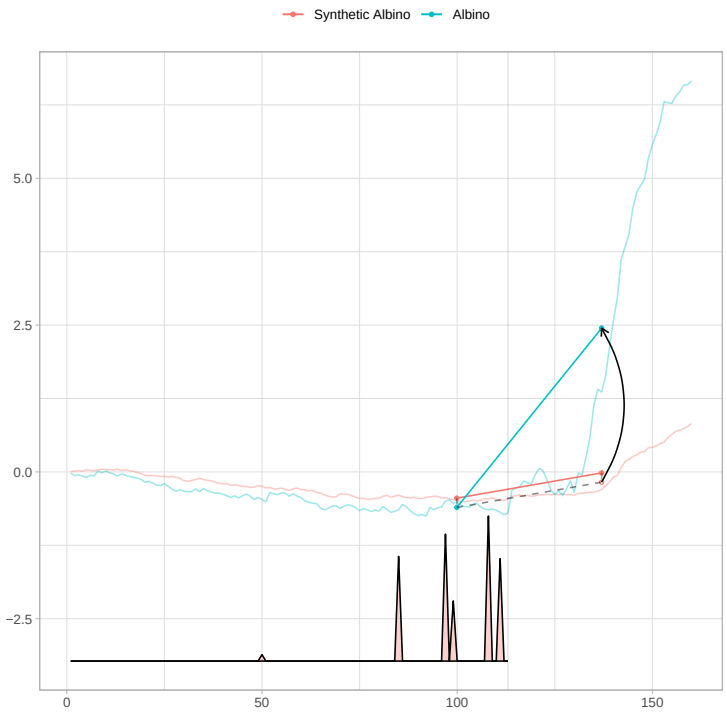
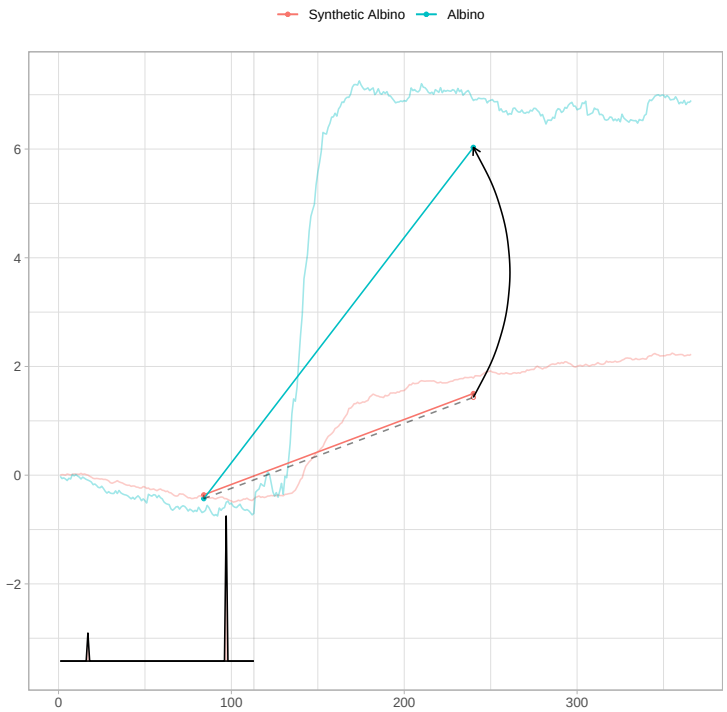
09-17
10-29
Days (Nov. 1, 2019 - Oct. 31, 2020)

SDiD: Albino


Synthetic Albino
Albino
5.0
2.5
0.0
−2.5
0
50
100
150


Synthetic Albino
Albino
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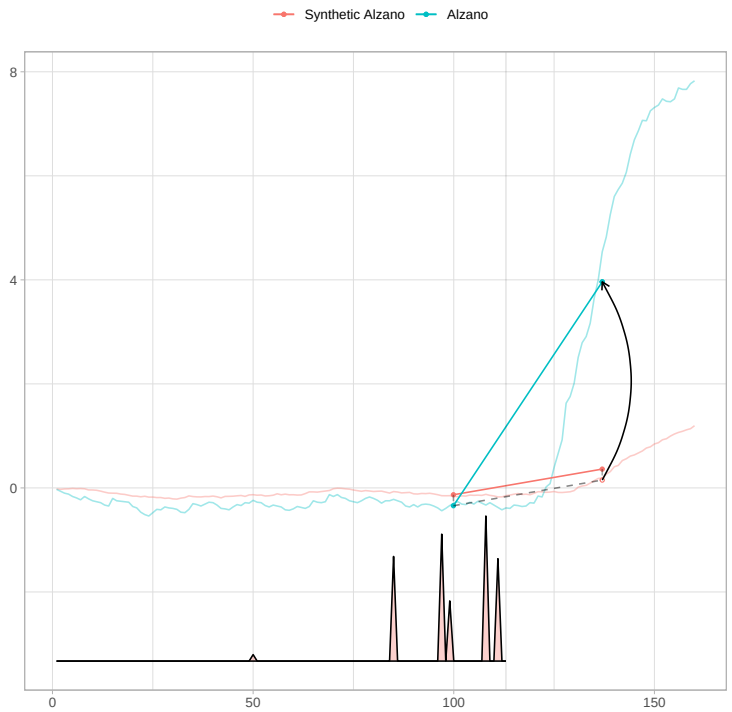
0
−2
0
100
200
300

SDiD: Alzano


Synthetic Alzano
Alzano
8
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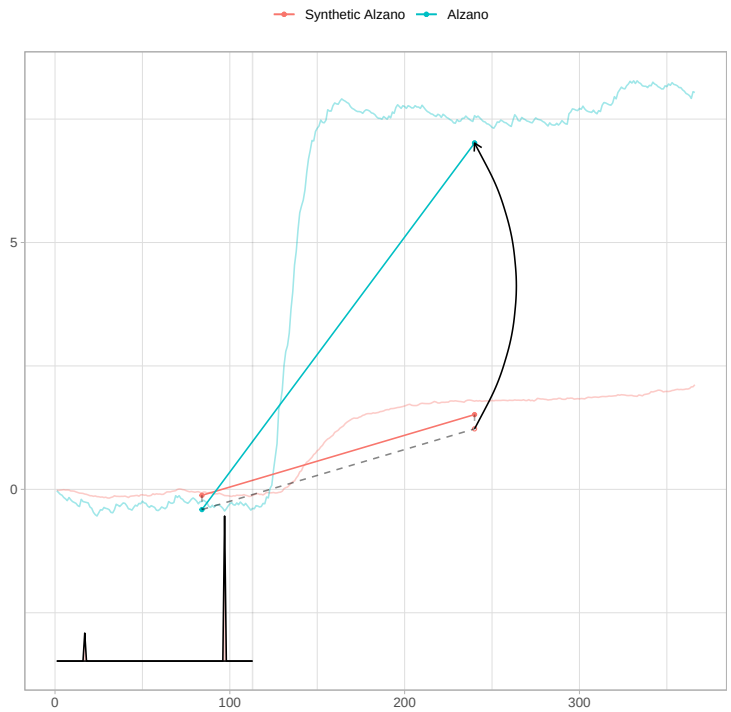
0
50
100
150


Synthetic Alzano
Alzano
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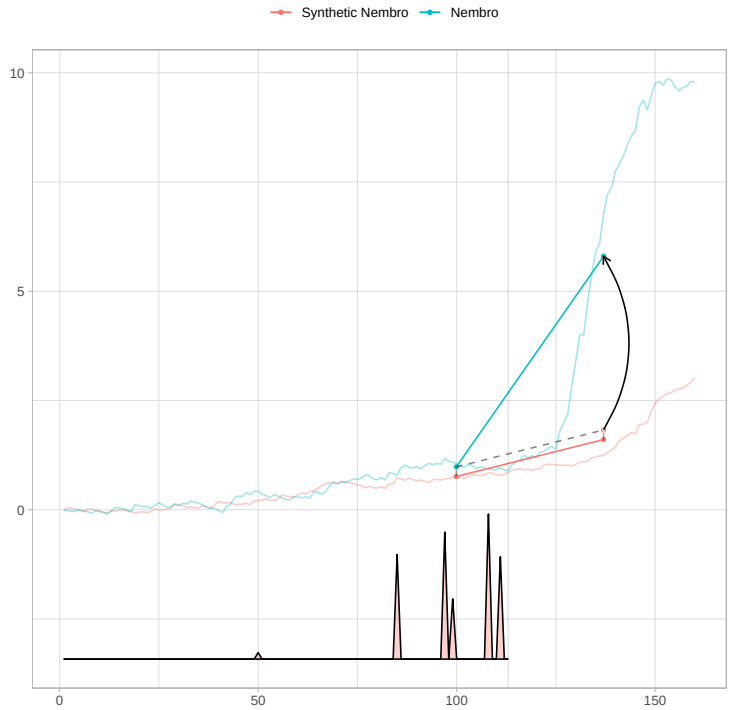
0
0
100
200
300

SDiD: Nembro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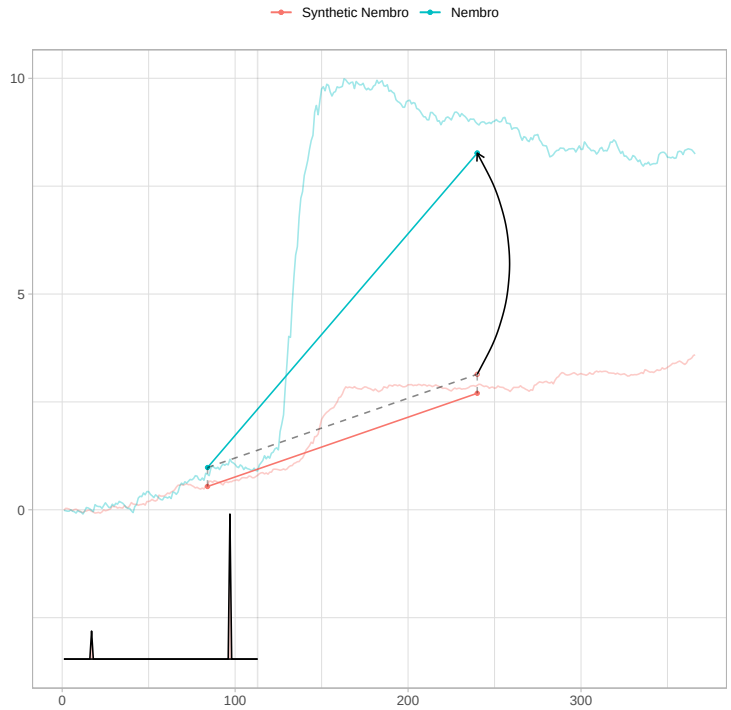

Synthetic Nembro
Nembro
10
5
0
0
100
200
300

Results: ASCM and SDiD estimates

	SCM	ASCM	SDID
Albino	4.61	5.14	4.60
Alzano Lombardo	6.73	7.59	5.79
Nembro	7.84	6.91	5.13

Inference and robustness tests

Inference and robustness tests

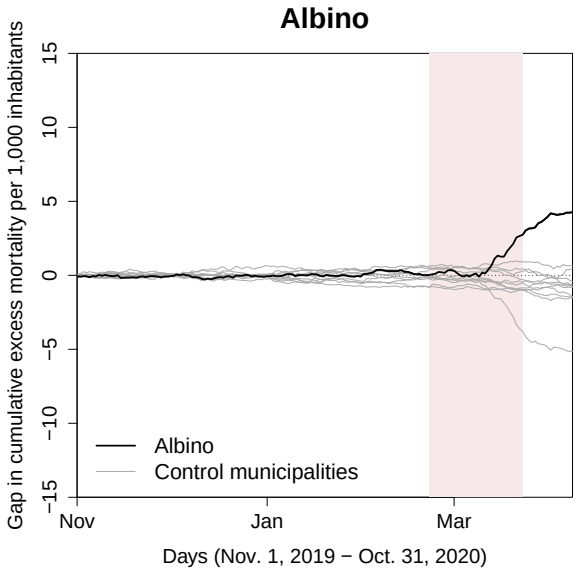
- In-space placebo tests RC1
- Leave-one-out analysis RC2
- Restricting donor pool to Red Zone Lombardy municipalities RC3
- Backdating of the intervention RC4
- Using a different starting date RC5

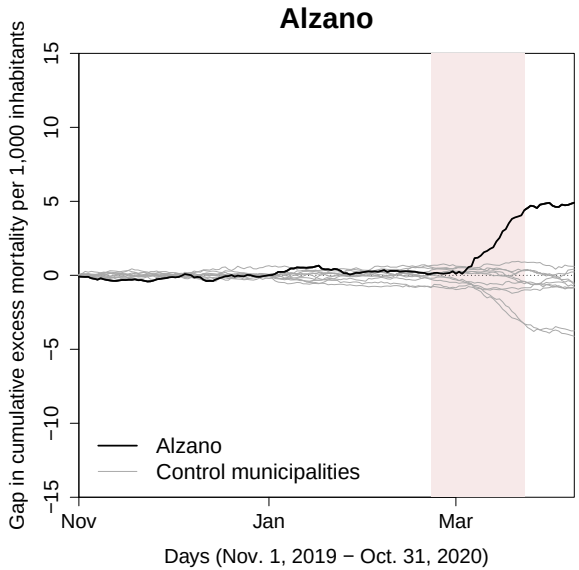
Conclusion

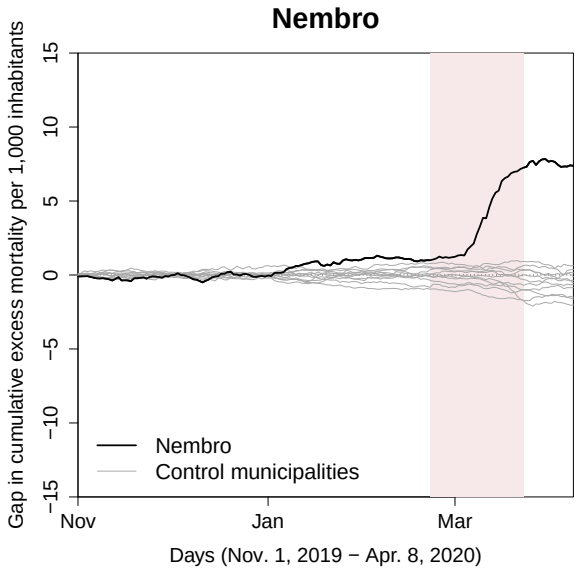
- Timely adoption crucial for NPIs' effectiveness.
- Introducing a Red Zone around the Serio Valley would have reduced the number of deaths by about two-thirds between March and April 2020.
- These results are robust to several standard checks and different methods.

Thank you for your attention

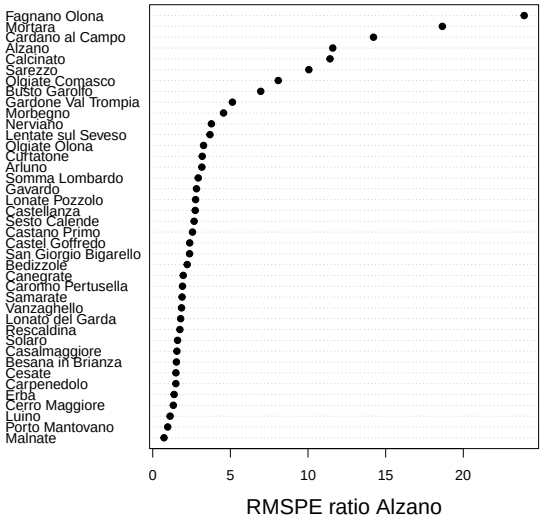
Placebo tests

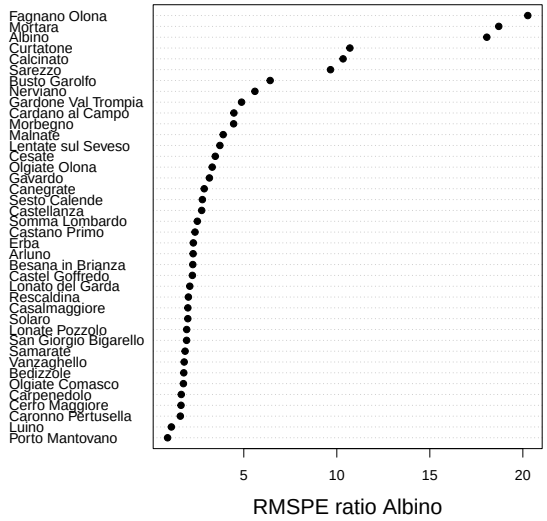


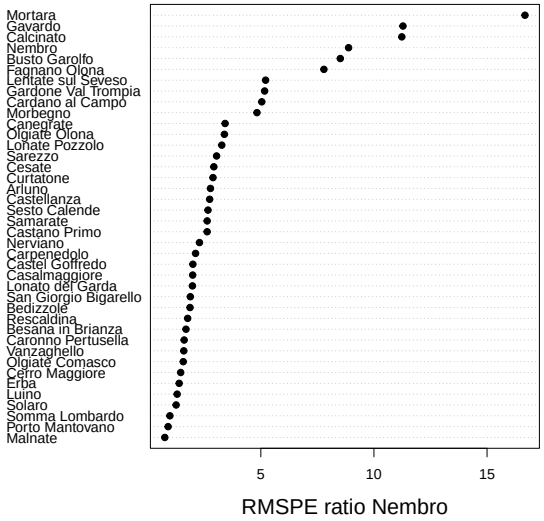




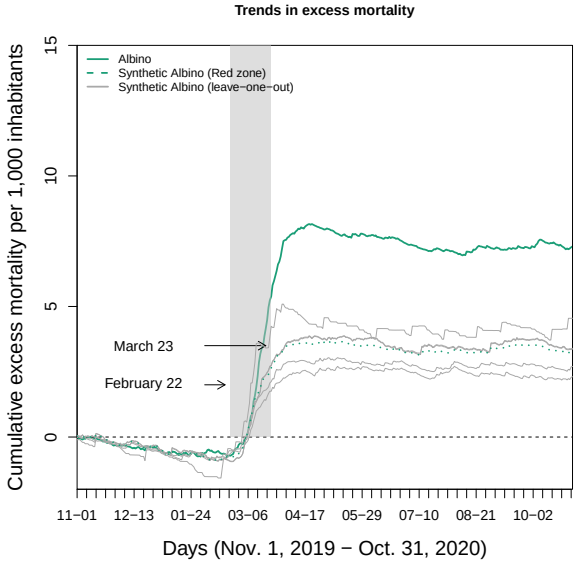
Ratio RMPSE Alzano

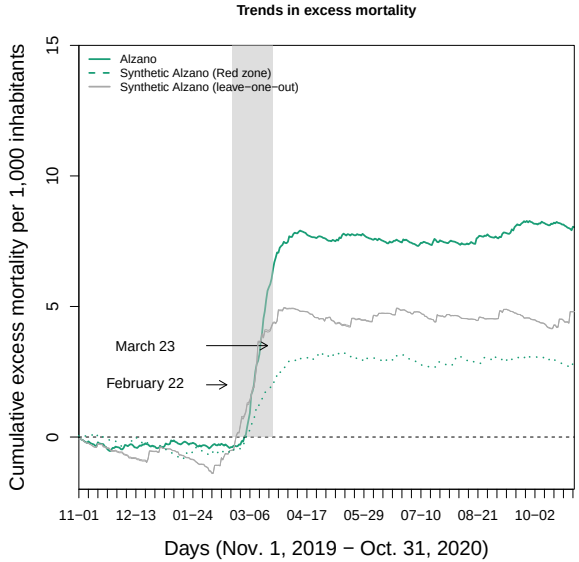


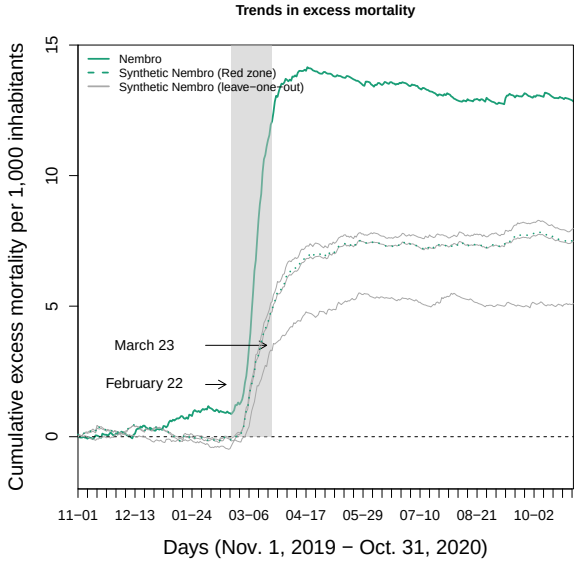




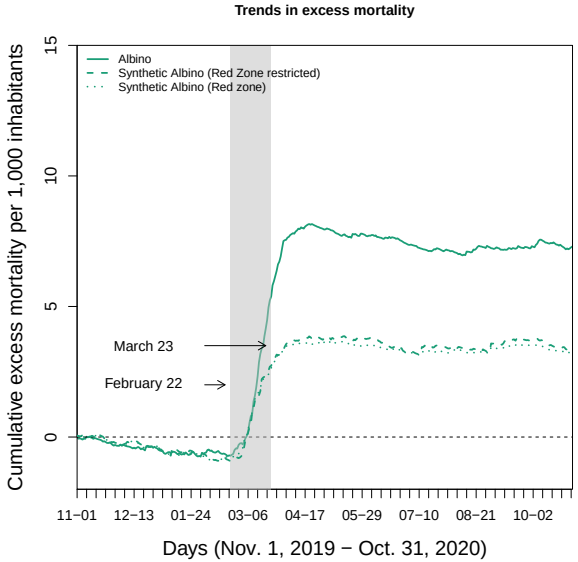
Leave-one-out estimates

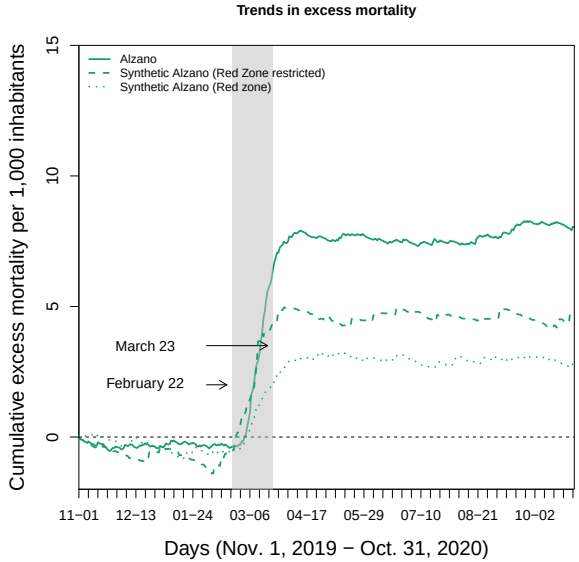


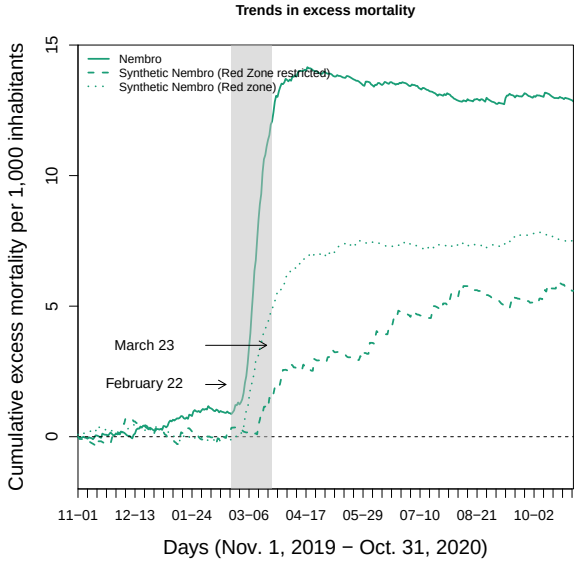




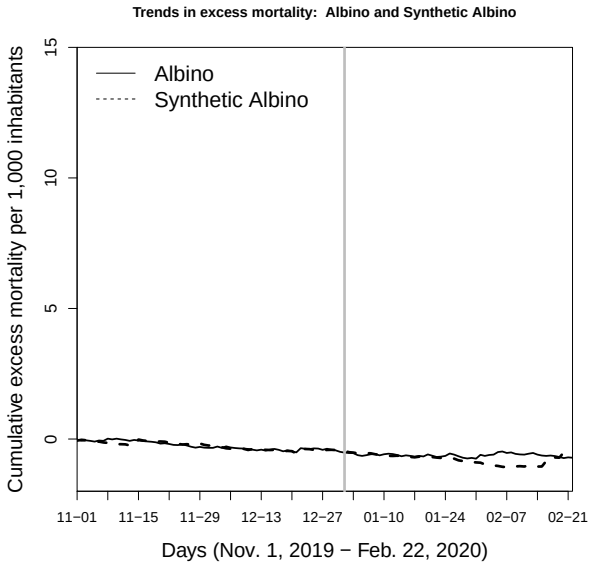
Restricting donor pool to Red Zone lombardy municipalities

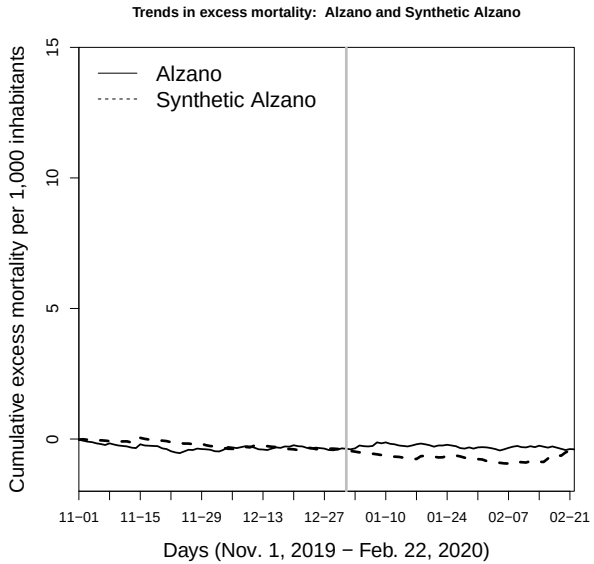


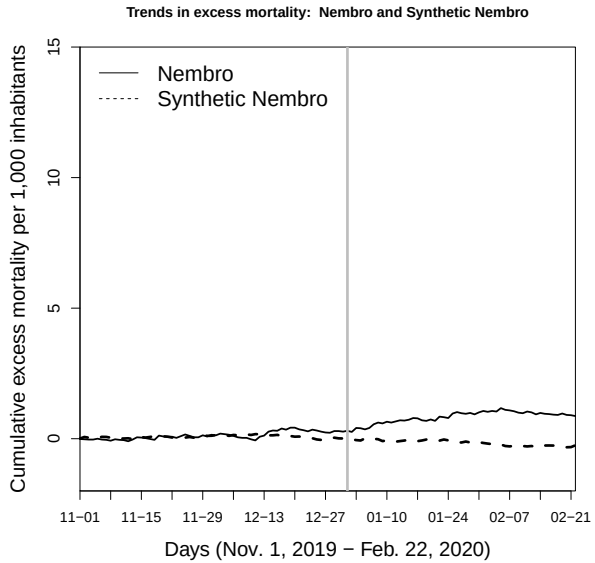




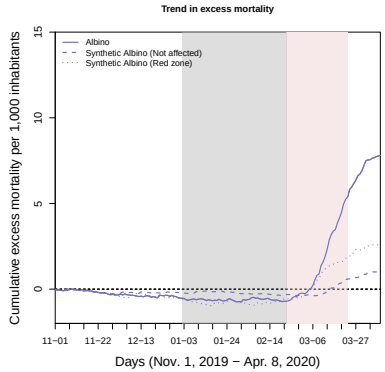
Backdating treatment date to January 1, 2020

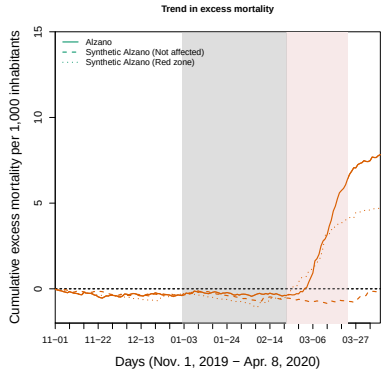


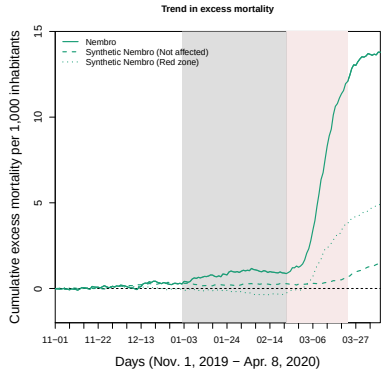




Moving treatment date to January 1, 2020







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Plausibility of NEPE