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COVID-19 in Italy: impact of containment measures and prevalence estimates of infection in the general population

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Abstract: Since the beginning of the COVID-19 epidemic in Italy, the Italian Government implemented several restrictive measures to contain the spread of the infection. Data shows that, among these measures, the lockdown implemented as of 9 March had a positive impact, in particular the central and southern regions of Italy, while other actions appeared to be less effective. When the true prevalence of a disease is unknown, it is possible estimate it, based on mortality data and the assumptive case-fatality rate of the disease. Given these assumptions, the estimated period-prevalence of COVID-19 in Italy varies from 0.35% in Sicily to 13.3% in Lombardy.

Key words: COVID-19, containment, prevalence, mortality

On April 7th, 2020, the number of notified COVID-19 cases in Italy is above 135,000, with almost 17,000 deaths (1). Italy, second only to the US for the number of COVID-19 notified cases, but first for of deaths, is facing an unedited challenge (2). The epidemic is disproportionately hitting some northern areas, pushing the Italian National Health Service capacity of some areas to their limits (3-5).

Lessons from China's successful battle against COVID-19 show how containing measures including cases isolation, contact tracing, and quarantine and mitigation measures, including general lockdown and social (or personal) distancing, seem to have worked (6-8).

As COVID-19 was first reported in Italy (23rd January 2020), the Government has progressively introduced restrictive measures (1,9). The most relevant actions taken by the Government from 25 January to 21 March 2020, are described in Table 1. Prevention measures, taken in late January, such as health-checkpoints in airports and a flight ban from China, rapidly escalated when the first autochthonous cases were detected in the area of Casalpusterlengo, Castelnuovo d'Adda and Codogno in the Lombardy Region (21 February) (Figure 1).

Containment measures at first had been the self-isolation of infected patients and the creation of a "red-zone" in a limited area. Afterward, the Government strategy changed into a severe mitigation response, up to the lockdown to all the country. Other mass-measures were introduced, such as a strong recommendation to avoid at-risk behaviors and the suspension of all non-essential businesses in the entire nation.

The proportion of the infected population in Italy was estimated based on available published Italian data. This preliminary analysis did not consider infections notified within the national surveillance system to avoid biases due to the heterogenous proportion of population tested in different regions (1). The number of official deaths was considered to be less biased; therefore, we included an adjustment in our model due to the undiagnosed deaths, especially in the first phase of the epidemic (10). The average increase of 20% in the number of deaths was introduced accordingly to a recent Italian specific report (11). The adjusted case-

Table 1. Health protection measures against COVID-19 in Italy, 25 January- 23 March 2020

Date	*Public health measure implemented*	*Place*	*Authority*
25/01	**Health checkpoints for passengers** coming from China or from areas where one sustained autochthonous transmission of the new Coronavirus has occurred.	Airports, Italy	Ministry of Health
30/01	**Air traffic from China is banned**	Airports, Italy	Government
21/02	**Mandatory supervised quarantine for 14 days** for all individuals who have come into close contact with confirmed cases of disease; **Mandatory communication** to the Health Department from anyone who has entered Italy from high-risk of COVID-19 areas, followed by **quarantine and active surveillance**.	Public Health department in identified areas	Ministry of Health
23/02	**Red zones**: adoption of an adequate and proportionate containment and management measures in areas with >1 person positive to COVID-19 with unknown source of transmission.	11 municipalities in Lombardy Region	Government
23/02	**Suspension of all public events** or open to the public, of any nature; Schools (all levels), public places, gyms, and other places of aggregation	5 Regions in Northern Italy	Ministry of Health
02/03	**Proposal to extend the "red zone"** to three additional municipalities in the provinces of Bergamo and Brescia from local authorities	Three municipalities in Lombardy Region	(not adopted)
08/03	**The "national" Red Zone**: avoid any movement of people except for motivated by proven work needs or situations of necessity (health, food and assistance); public and private employers should encourage to use days of ordinary leave and holidays and smart working; closing of ski facilities; limit travel and activities and sanitization measures and reduce close contacts	Lombardy Region (and other affected areas in 5 additional regions)	Government
11/03	Suspension of all business activities; **Suspension of all commercial activities non-indispensable for production**. Maximum use by companies of smart-working methods for activities that can be performed at home or remotely. Sanitation of workplace areas.	Italy	Government
23/03	**Extension of the ban on non-indispensable activities.** A list of 80 authorized activities is published. The ban extends limitations on individual freedom and on other business activities that were not explicitly closed by the previous measures.	Italy	Government

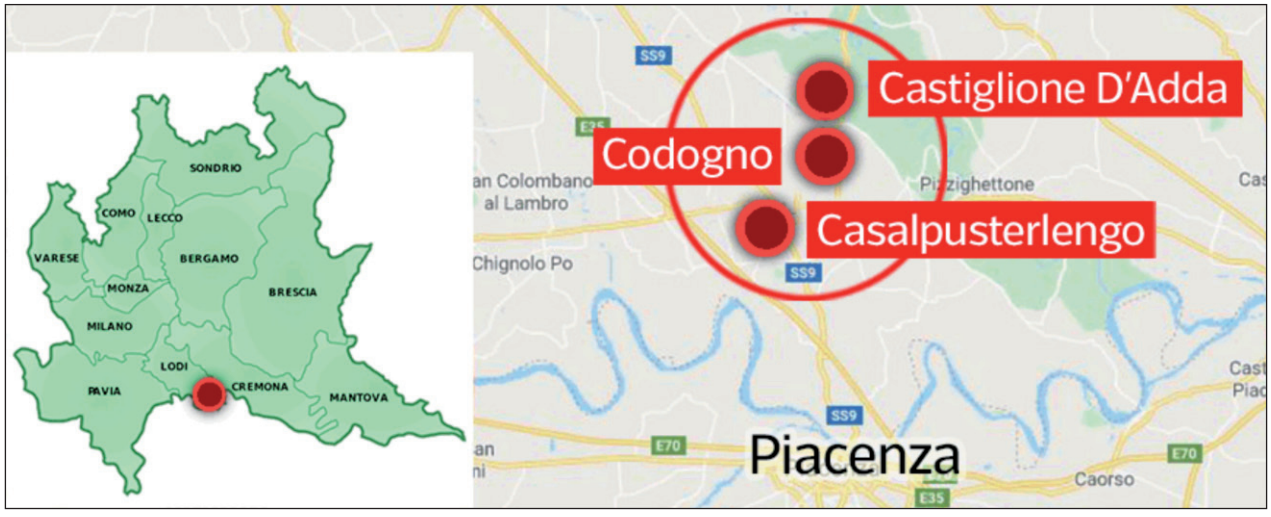

Figure 1. First "Red Zone" Area (February 23rd)

fatality rate for Europe (0.85%) was derived considering the averaged estimates of three reports, two carried out in UK and the other in Italy (12-14). From these parameters, we obtained a model to estimate the current period prevalence in the general population of the 19 Italian regions and the 2 autonomous provinces (Table 2). These data vary among Italian regions from 0.35% infection proportion in Sicily and Basilicata to 11.2% in the Lombardy region and are a useful tool to inform the planning of further containment measures in different geographical areas.

Conclusions

The epidemic showed an evident spread. If we analyze these trends, we can outline the following, preliminary considerations:

a) The measures to suspend flights from China (which were not adopted by other EU countries) and airports' checkpoints with *thermoscan* did not have a significant effect in containing the epidemic.
b) The implementation of a "red zone" in Lombardy effectively contained the spread of the infection within that area. On the other hand, the "red zone" measure did not have the same effect outside that area. In fact, three of the neighboring provinces (Bergamo, Brescia, and Piacenza) recorded the highest incidence rates in the weeks following the establishment of the red zones (1,5). Perhaps these actions were adopted too late (or considering a too small area) when the virus had already spread for several days without notice of it.
c) The failure to establish a second "red zone" near Bergamo in the Municipalities of Alzano and Nembro (Figure 2), despite the proposal of local authorities (on March 3rd), led to a dramatic outbreak with about 10,000 cases in Bergamo with over 1,000 death toll and similar figures in the

Table 2. Population, Number of deaths and estimates of infection period prevalence in the Italian Regions and Autonomous Provinces

Regions and Autonomous Provinces	*Population M (mil)*	*N. of deaths*	*Period Prevalence*
Piemonte (Piedmont)	4.4	1.319	4.3%
V.d'Aosta (Aosta Valley)	0.13	100	11.2%
Lombardia (Lombardy)	10.1	9.484	13.3%
Prov. Aut. Bolzano	0.52	174	4.7%
Prov. Aut. Trento	0.54	244	6.4%
Veneto	4.9	695	2.0%
Friuli-Venezia Giulia	1.3	164	1.8%
Liguria	1.6	620	5.6%
Emilia-Romagna	4.5	2.180	6.9%
Toscana (Tuscany)	3.7	369	1.4%
Umbria	0.88	49	0.78%
Marche	1.5	630	5.8%
Lazio	5.9	238	0.57%
Abruzzo	1.3	172	1.9%
Molise	0.31	13	0.60%
Campania	5.8	216	0.53%
Puglia (Apulia)	4.0	209	0.73%
Basilicata	0.56	14	0.35%
Calabria	1.9	60	0.43%
Sicilia (Sicily)	5.0	125	0.35%
Sardegna (Sardinia)	1.6	52	0.45%
Total Italy	60.4	17.127	4.0%

Figure 2. Missed "Red Zone" Area (March 3rd), from Regione Lombardia & Corriere della Sera

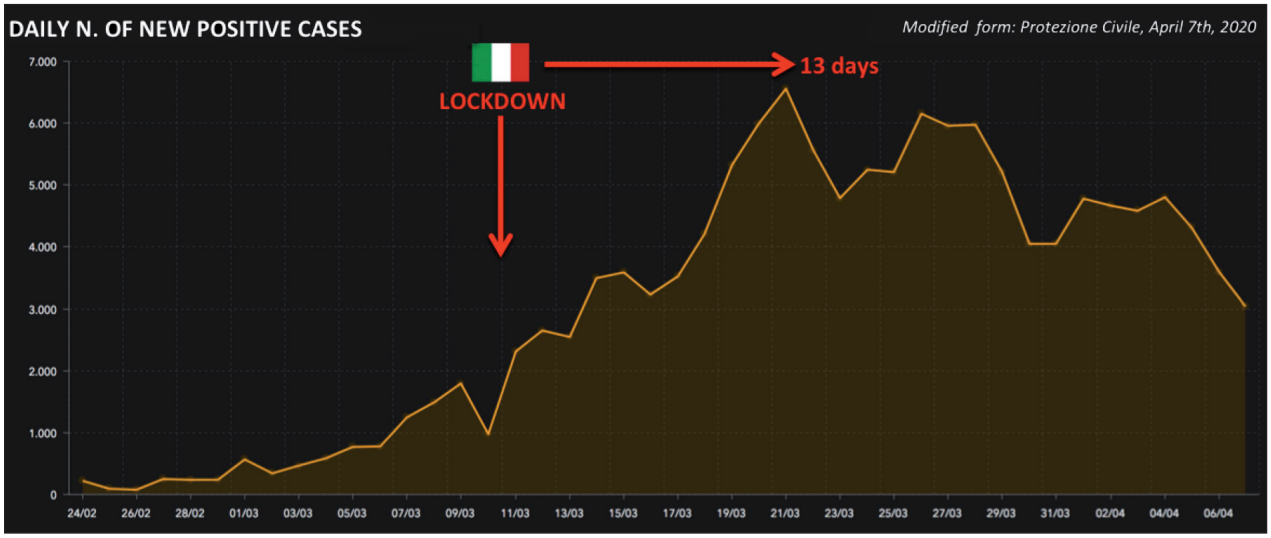

Figure 3. Trend of overall new notified cases in Italy (Protezione civile, 7,4,2020)[1]

neighboring areas (Brescia and Piacenza) (5).

d) General mitigation measures seem to be effective to flatten the epidemic curve of new notified infections (Figure 3) with more effect in controlling the epidemic in the central-southern than in the Northern regions (1).

The difference was in the time when the mass-measures were adopted. At the time of the national lock-down, the central-southern regions only had few circulating cases. Timing appeared to be a crucial factor in determining the effect of mitigation measures (Figure 4).

Overall, containment measures (red zones) and mitigation (general lockdown) can be effective if taken at an early stage of the epidemic ad on large areas. Also, the community management of suspects, contacts, and cases could alleviate hospital burden and perhaps even improve disease prognosis.

The post-epidemic phase might benefit from the availability of forthcoming antibody serological tests. The benefit could be substantial for a large part of the country population, but especially central and southern Italy, that would not yet be infected, as shown by our estimates.

Figure 4. Estimate of Period Prevalence of infected people in the Italian regions as at 7 April, 2020

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