Measuring the effectiveness of COVID-19 containment policies in Italian regions: are we doing enough?

Demetrio Panarello, Giorgio Tassinari

1. Introduction

The Coronavirus disease 2019 (COVID-19), caused by the SARS-CoV-2 virus, was first identified in Wuhan, China, in December 2019. The disease quickly spread to the rest of the world. The earliest cases of Italian citizens infected by the virus were detected on the 21st of February 2020 (Romagnani et al., 2020). Italy was sent into a severe lockdown on the 10th of March (Verma et al., 2020) and emerged from it on the 4th of May, slowly starting to reopen its economic activities (Buonomo and Della Marca, 2020).

While the lockdown conveyed a message of danger, the reopening might have led citizens to perceive that the threat had come to an end (Reinders Folmer et al., 2020). Indeed, during the lockdown, inhabitants were obliged to confine themselves under severe penalties; after that, the issue was confidently put into citizens' hands, who were now able to choose how much they were willing to cooperate. An effective response to the pandemic relies heavily on citizens' compliance with the restrictive measures put in place to halt its spread (Sobol et al., 2020), ultimately reducing the number of deaths.

With this paper, we aim at giving an insight into how Italian citizens' compliance with the restrictions – measured through longitudinal data on sanctions and movement trends – has affected the number of deaths over time. Moreover, we investigate what would have happened if, in the event of insufficient compliance on the part of citizens, heavier restrictions were put in place. In so doing, we provide an estimate of how many human lives could have been spared as a result of stricter public health regulations.

2. Data and Methods

Our data come from several sources of information. For each considered variable and each of the 107 Italian provinces, we collected 260 daily observations, pertaining to the period running from the 24th of February to the 9th of November 2020.

First, we collected the daily distribution of COVID-19 positive cases, performed swabs, and recorded deaths in the country's 19 regions and 2 Autonomous provinces, provided by the Italian Civil Protection (Dipartimento della Protezione Civile, 2020). To each province, we associated the corresponding regional values. Country-level daily swabs (in thousands), positive cases (in hundreds), and deaths are plotted in Figure 1. The number of swabs, which was remarkably low at the beginning of the pandemic, shows a major increase in the second half of the considered period. At this point, the deaths line starts keeping pace with the swabs one, so that the number of deaths becomes close to 1 per 100 positive cases.

Furtherly, we made use of the Containment and Health Index, developed by the University of Oxford's Blavatnik School of Government (Hale et al., 2020), tracing the government response to the pandemic outbreak over time. It is a composite index made up of 12 country-level indicators on closings of schools and universities, closing of workplaces, cancelling of public events, restrictions on private gatherings, closing of public transport, stay-at-home requirements, restrictions on internal movements, restrictions on international travel, presence of public information campaigns, testing policy, contact tracing, and facial coverings policy.

Moreover, we gathered the number of daily controls and fines imposed on citizens due to

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disrespecting the COVID-19-related restrictive measures, made available by the Italian Ministry of the Interior (Ministero dell'Interno, 2020) at the national level. We can calculate the sanction rate as the ratio between the number of fines and the number of people who were controlled on a given day; the compliance rate is the one's complement to this rate, which represents a proxy of citizens' degree of adhesion and consent to the measures aimed at containing the Coronavirus spread.

Additionally, we employ Google's Community Mobility Reports, capturing movement trends across various locations at the province level (Google LLC, 2020). We include five categories of places: retail stores and recreation sites, grocery stores and pharmacies, parks, transit stations, and workplaces. The data consist in daily per cent variations in the number of visitors compared to a pre-pandemic baseline.

Finally, we include some variables describing the demographic characteristics of the Italian provinces, taken from the Italian National Institute of Statistics (Istat): activity rate, population density, and ratio of over-65s to the total population.

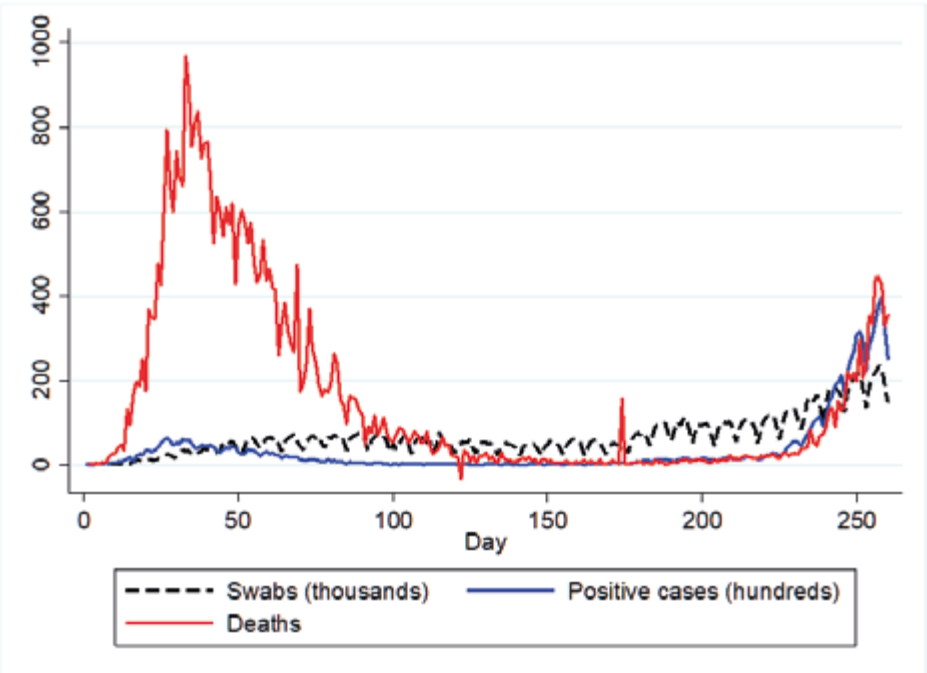

Figure 1 – Swabs, positive cases and deaths over time (Italy, 24 February – 9 November 2020).

We estimate Negative Binomial regressions of the regional deaths count on regional positive cases, regional swabs, Containment and Health Index, Compliance rate, Google Mobility data (for retail and recreation, grocery and pharmacy, parks, transit stations, and workplaces), activity rate, population density, and percentage of over-65s to the total population.

Indeed, as we employ a count variable as dependent, the correct investigation approach is given by regression models based on the Negative Binomial distribution (Chan et al., 2021). The time-varying variables are employed with a 17-day lag from the dependent variable, as we add the median time from the onset of symptoms to death, which was estimated in 12 days in Italy (Gruppo della Sorveglianza COVID-19, 2020), to the mean incubation period (i.e., the time between the contact with a positive individual and the onset of symptoms) of approximately 5 days (Linton et al., 2020). Our specifications employ the robust estimator of variance and do not include fixed effects.

We run the first model on the complete sample. Then, as the schools' reopening on 14

September 2020 is said to have been the primary cause of the resurgence of the pandemic in Italy (Sebastiani and Palù, 2020), we estimate the same model on two subsamples: until the 13th of September and since the 14th of September, which is marked as the beginning of the "second wave" of the pandemic.

Finally, we add up 10 points to the Containment and Health Index daily since the 1st of September, to investigate what would have happened if stricter public health regulations were put in place two weeks before schools restarted. Through this, we provide an estimate of how many human lives could have been spared in the period from 14 September to 30 October 2020 in the Italian regions affected by the highest lethality rate.

3. Results

The results of our estimations are shown in Table 1. As regards the number of deaths, analysed through Negative Binomial regression models, most variables are highly significant and show the expected signs. Our results confirm that the lockdown policies have had a beneficial impact on the pandemic, having been able to reduce the number of deaths caused by COVID-19. Moreover, the number of deaths exhibits a negative relationship with the Compliance rate.

Table 1 – Results from Negative Binomial regressions of regional deaths.

	Overall	**Until 13th Sep**	**Since 14th Sep**
	Coefficient (Robust S.E.)	**Coefficient (Robust S.E.)**	**Coefficient (Robust S.E.)**
Regional positive cases (lag 17)	0.002***	0.002***	0.001***
	(0.0001)	(0.0001)	(0.0001)
Regional swabs (lag 17)	0.000***	0.000***	0.000***
	(0.0000)	(0.0000)	(0.0000)
Containment and Health Index (lag 17)	-0.022***	-0.011***	-0.122***
	(0.0023)	(0.0027)	(0.0054)
Compliance rate (lag 17)	-0.345***	-0.314***	-1.283***
	(0.0170)	(0.0233)	(0.0710)
Google Mobility: Retail and recreation (lag 17)	-0.028***	-0.028***	-0.011***
	(0.0022)	(0.0028)	(0.0032)
Google Mobility: Grocery and pharmacy (lag 17)	0.023***	0.021***	0.014***
	(0.0010)	(0.0011)	(0.0023)
Google Mobility: Parks (lag 17)	-0.001*	0.002***	-0.003***
	(0.0004)	(0.0005)	(0.0005)
Google Mobility: Transit stations (lag 17)	-0.007***	-0.018***	-0.003**
	(0.0012)	(0.0018)	(0.0011)
Google Mobility: Workplaces (lag 17)	0.007***	0.007***	0.013***
	(0.0012)	(0.0015)	(0.0016)
Activity rate	0.038***	0.070***	-0.012***
	(0.0027)	(0.0030)	(0.0029)
Density (pop. per sq. km)	0.000	0.000	0.000***
	(0.0000)	(0.0000)	(0.0000)
Percentage of over-65s to total population	0.063***	0.093***	0.017**
	(0.0059)	(0.0074)	(0.0068)
Intercept	32.166***	25.240***	136.106***
	(1.6180)	(2.2958)	(7.3005)
Log-transformed over-dispersion parameter (ln α)	0.178***	0.105**	-0.364***
	(0.0290)	(0.0449)	(0.0283)
Observations	21641	16741	4900
McFadden's pseudo R^2	0.163	0.187	0.144
Log-pseudolikelihood	-54050.46	-39330.62	-13235.40

*Notes: *, ** and *** stand for $p < 0.10$, $p < 0.05$ and $p < 0.01$.*

We replicated the analysis by dividing the sample into two subperiods: the first one until the 13th of September and the second one since the 14th of September. The results roughly confirm those from the analysis carried out for the whole period, demonstrating the goodness of the model. Nevertheless, some regressors change their sign from one period to the other: mobility towards parks is positive in the first period, but negative in the second one, and the same goes for activity rate. Moreover, the magnitude of some coefficients changes considerably. In particular, the coefficient for Compliance rate in the second period is over four times that of the first period; additionally, the coefficient for Containment and Health Index shows an increase of about 11 times. This means that the importance of the restrictive measures and of citizens' accord on their abidance has greatly increased since the end of the summer, also because the stringency level of the adopted measures has critically declined, which was preparatory to the formation of the "second wave" of the pandemic. Finally, the share of population aged 65 or more always shows a positive sign, which reflects the known situation of higher lethality characterising the elderly population (Rinaldi and Paradisi, 2020). However, in the second period, its coefficient is about one fifth that of the first period: indeed, this shows that the demographic dynamics of the pandemic have changed compared to the beginning and that the elderly have become more cautious in the second phase of the pandemic.

Trying to sum up our achieved outcomes, the restrictions represented by the Containment and Health Index appear essential to contain the pandemic until the vaccination campaign has produced the so-called herd immunity. However, these restrictions are not sufficient when they are not accompanied by citizens' consent, which translates into adherence to the mobility restrictions, observed through the reduction in Google mobility indices: indeed, it is not realistic to think that repressive actions are enough to enforce compliance with the new mobility rules.

Finally, we add up 10 points to the Containment and Health Index since the 1st of September, providing a prediction of the deaths count from 14 September to 30 October 2020 in the six Italian regions affected by the highest overall lethality rate, in the hypothesis of higher stringency put in place starting from two weeks before the reopening of schools. These simple estimates do not consider the variations in compliance and mobility which could result from a hypothetical change in stringency. The results are summarised in Table 2 and plotted in Figure 2.

Apart from Valle d'Aosta, which experienced a low number of deaths due to its small population size, the predictions show that a significant number of losses could be averted by introducing more restrictions in good time before schools restarted. In particular, Lombardia – the region in which the outbreak started – could have saved 429 lives just between 14 September and 30 October, compared to the 563 deaths faced in the same period (-76.20%).

Table 2 – Count of deaths and cases, population, Case Fatality Rate, Lethality Rate, deaths averted.

Region	Deaths 14th Sep – 30th Oct	Cases 14th Sep – 30th Oct	Population	CFR 14th Sep – 30th Oct	Lethality Rate 24th Feb – 30th Oct	Deaths averted 14th Sep – 30th Oct	Deaths averted (per cent)
Lombardia	563	83486	10103969	0.67%	0.173%	429	76.20%
Valle d'Aosta	20	1876	125501	1.07%	0.132%	-68	-
Liguria	170	15688	1543127	1.08%	0.113%	129	75.88%
Emilia-Romagna	143	20293	4467118	0.70%	0.103%	86	60.14%
Piemonte	202	33996	4341375	0.59%	0.100%	158	78.22%
P.A. Trento	32	3247	542739	0.99%	0.081%	3	9.38%

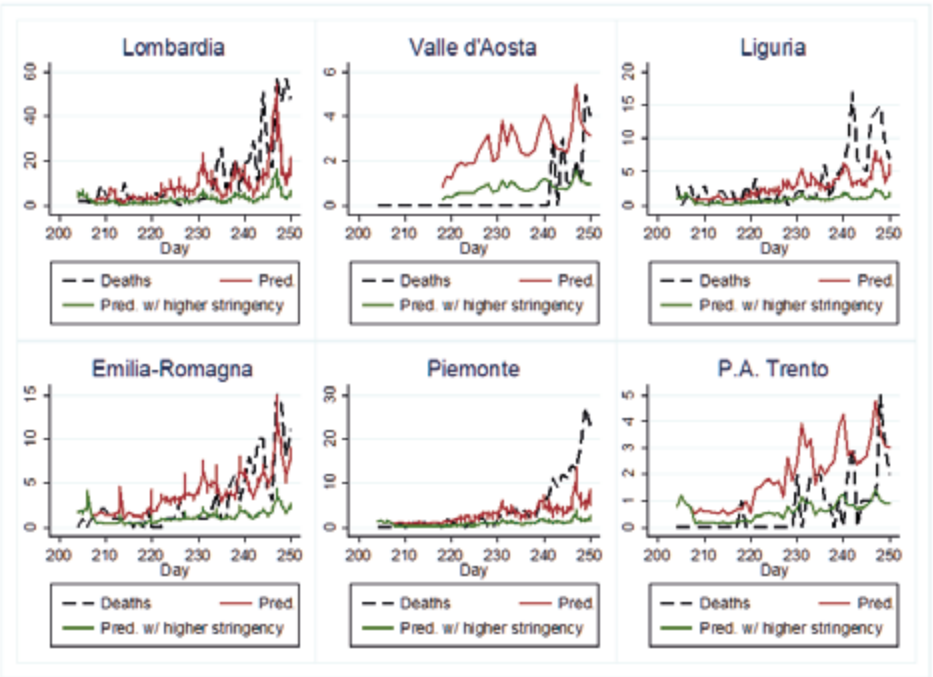

Figure 2 – Deaths over time, real prediction, prediction in the case of higher stringency level.

4. Conclusive remarks

We should be aware that mitigating the spread of infections is a cooperative process: hence, all policymakers (State and Regional authorities) should manage communication to motivate the citizens and avoid contradictory behaviours that confuse the population. Indeed, it is necessary to act to address people's behaviours, as the defeat of COVID-19 begins in people's minds.

But it is not just a psychological and political communication problem. The role played by the closure of workplaces, except for essential activities, should also be borne in mind. In the period that began on the 14th of September, the contribution of workplace-related mobility to the deaths count has almost doubled, which leads us to question whether in the second phase of the pandemic there has been some hesitation in taking more incisive measures, such as the partial closure of productive activities.

As we have seen, we would have been saved hundreds of deaths if more restrictions were promptly introduced before schools' reopening. With no additional interventions, the number of lost lives will eventually become much greater than that suffered in the very first period of the pandemic (Vollmer et al., 2020). Moreover, it should be remarked that timeliness in introducing restrictive measures is essential to reduce their required duration (Chang et al., 2020).

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