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On the management of COVID-19 pandemic in Italy

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A R T I C L E I N F O

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A B S T R A C T

The fast-moving coronavirus disease 2019 (COVID-19) called for a rapid response to slowing down the viral spread and reduce the fatality associated to the pandemic. Policymakers have implemented a wide range of non-pharmaceutical interventions to mitigate the spread of the pandemic and reduce burdens on healthcare systems. An efficient response of healthcare systems is crucial to handle a health crisis. Understanding how non-pharmaceutical interventions have contributed to slowing down contagions and how healthcare systems have impacted on fatality associated with health crisis is of utmost importance to learn from the COVID-19 pandemic. We investigated these dynamics in Italy at the regional level. We found that the simultaneous introduction of a variety of measures to increase social distance is associated with an important decrease in the number of new infected patients detected daily. Contagion reduces by 1% with the introduction of lockdowns in an increasing number of regions. We also found that a robust healthcare system is crucial for containing fatality associated with COVID-19. Also, proper diagnosis strategies are determinant to mitigate the severity of the health outcomes. The preparedness is the only way to successfully adopt efficient measures in response of unexpected emerging pandemics.

1. Introduction

The coronavirus disease 2019 (COVID-19) has spread quite rapidly. Emerged in the city of Wuhan (China) in December 2019, the new infectious agent, a severe acute respiratory syndrome (SARS-CoV-2), propagated mainly through person-to-person contact [5, 11]. On January 30, 2020, the World Health organization (WHO) declared COVID-19 a Public Health Emergency of International Concern [30] and, within a few months since its recognition, COVID-19 has reached more than 200 countries. The COVID-19 outbreak has become one of the worst global pandemics [7], with more than 128 million people infected and nearly 3 million of deaths claimed as of March 31, 2021. The economic impacts of the pandemic are enormous, especially due to business closures imposed to limit the contagions: the IMF [16] has estimated that global economy, in 2020, had acontraction equal to 3%: in Europe this tendency is observed on every month with business closures [14].

The pandemic has called for a rapid international response to slow down the transmission of contagions and reduce the fatality rates associated with COVID-19. High pressure on healthcare systems, due to peak load hospitalisations and critical care requirements, tend to worsen the consequences of the health crisis [28]. Due the lack of vaccines or specific therapies to combat the COVID-19 during the first wave, policymakers, in different regions of the world, have proposed non-pharmaceutical interventions, such as lockdown and social distancing measures [14, 26]. Understanding the effectiveness of these interventions has become an important goal to help containing the pandemic, especially in regions where the healthcare is weaker, and thus the fatality rates tend to be higher [18]. Limiting interactions reduces contagions, at a high cost for the economic activities, despite massive policy interventions to mitigate the economic crisis [31]: according to the IMF, among advanced economies, Australia, Japan, UK, and US have allocated more than 15% of their GDP to interventions related to the pandemic, whereas China and Italy (the first countries hit by COVID-19) have allocated, respectively, 4.7% and 6.8% of their GDP; also low-income countries (e.g., African countries) have devoted few percentage points (about 2.5%) of their GDPs(see figure A.1 in the Appendix A.1).

However, the policy measures need to be transitory interventions, unsustainable in the long-run, and without plans to flatten the contagion curve, and to reduce the deaths due to COVID-19. We investigate and quantify the efficacy of non-pharmaceutical interventions, such as lockdown and social distancing policies in reducing contagions. Second, we analyze how differences in the management of the epidemic relates to the (regionally) heterogeneous impacts of the pandemic.

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We focus on the Italian case: according to data from the Italian Department of Civil Protection on the first wave, there have been, on average and on a daily basis, 1.3% new infected patients and a fatality rate close to 42.2%. Marked differences have been observed across regions: for instance, during the first wave, several Northern regions have been more affected than the Southern and Central regions. The Italian case study is important also for another reason: in Europe, Italy has been the first country to implement non-pharmaceutical interventions [10]. The Italian government declared the state of emergency on January 31, 2020,introduced measures for social distancing on February 23, and started the on March 09 (until May 03): the longest quarantine in the history of the country [10]. The Italian case study is also very informative because the National Health Care System provides complimentary universal coverage for comprehensive and essential health services, with regional differences in processes (i.e., appropriateness in the use of the resources) and outcomes [25].

We complement the analysis provide by Becchetti et al. [2], who have also investigated the Italian case (see section A.2 of the appendix for a detailed comparison). Differently from Becchetti et al. [2], we deepen more on the interventions to enhancesocial distancing, disinfection of public transports, and on regional differences in healthcare systems management.

The next sections review the studies on interventions during pandemics, describe the empirical approach to model the spread of contagion and the fatality rates, and provide elements for the debate. We conclude with reflections on policy implications.

2. Existing studies on interventions during pandemics

Managing the spread of infectious diseases, and pandemics, is very complex [19], especially when vaccines are not available [8] and the herd immunity is hard to be reached [20]. The non-pharmaceutical interventions to increase social distance, may help reducing contagions [9], as it has been evident for the influenza pandemic in 1918 [15], for the severe acute respiratory syndrome (SARS) in 2003 [3, 17], and for the influenza A in 2009 (H1N1) [21]. . Social distancing and lockdown policies seem to be effective also for the COVID-19 pandemic (e.g., [7, 10]). Details are provided in section A.3 of the Appendix.

The role of healthcare systems, in improving and maintaining population health, and ensuring equitable access to healthcare, has also been investigated so (e.g., [25, 29]). Nixon and Ulmann [24] found that highly efficient healthcare systems reduce with the fatality rates, but also the availability of resource [18] and a timely supply of medical resources [32] matter.. A limitation of these analyses relies on their explorative (qualitative) nature that prevent a quantification of the effects.

3. Materials and methods

3.1. Contagions

We study the daily region-specific growth of COVID-19 cases (G_{it}) as ratio of daily change in new infected patients in each region ($A_{it} - A_{it-1}$) over the number of swabs in that region (S_{it}):

$$G_{it} = \frac{A_{it} - A_{it-1}}{S_{it}} \tag{1}$$

where the subscript i indicates regions and varies from 1 to 21 (i.e., Piemonte, Valle d'Aosta, Liguria, Lombardia, Trentino-Alto Adige – divided in Provincia Autonoma di Bolzano and Provincia Autonoma di Trento–, Veneto, Friuli-Venezia Giulia, Emilia-Romagna, Toscana, Umbria, Marche, Lazio, Abruzzo, Molise, Campania, Puglia, Basilicata, Calabria, Sicilia, Sardegna) and the subscript t indicates time (days), from 1 (February 24, 2020) to 70 (May 3, 2020). By normalizing for the number of swabs we control for different regional approaches (i.e., pro-swabs vs. no-swabs) and for region-specific capabilities in processing swabs.

The timing of the policy interventions varies across regions. We estimate a linear panel data model . We include regional dummies ($\boldsymbol{\alpha}_i$), time trend and time dummies ($\boldsymbol{\alpha}_t$) to control for spatial and temporal unobserved heterogeneities [6]:

$$G_{it} = \alpha + \boldsymbol{\alpha}_i + \boldsymbol{\alpha}_t + \boldsymbol{\beta}\boldsymbol{P}_{it-14} + \gamma\,\Delta R_{it} + \upsilon_{it} \tag{2}$$

where the regional daily evolution of contagions (*cfr*. Eq. (1)) is function of the date of entry into force of policy interventions, delayed by 14 days ($\boldsymbol{P}_{it-14}$). We control crowding effects [1] with the changes in number of recovered patients (ΔR_{it}). The terms $\boldsymbol{\beta}$ and $\boldsymbol{\gamma}$ stand for the vectors of parameters, while α and υ_{it} are, respectively, the constant and the error term. We consider policy interventions such as measures of lockdown, disinfection of public transports and social distancing (include.g. suspensions of events and teaching activities, closures of fitness and wellness activities, of retail business parks, and industries). Following Acemoglu et al. [1], these policy interventions variables range from 0 to 1, being 0 for regions under no lockdown and 1 for regions implementing a full lockdown: intermediate values account for partial regional lockdowns, occurring when lockdowns are limited to some of the regional provinces.

We test the robustness of our findings by controlling for regional characteristics such as the yearly mean values of PM10, the population density, and the distance from the main locus of the Italian epidemic, Lombardia.

In short, the Eq. (2) models the infectiousness and its relationships with policy interventions, level of pollution (proxied by the level of PM10) and population density. The standard errors are geographically clustered (around Italian macro-regions) to limit potential errors correlation across within each macro-region (North West, North East, center, South).

3.2. Fatality ratios

We compute the fatality ratio (F_{it}) as ratio of number of deaths for COVID-19 over deaths for COVID-19 plus recoveries from COVID-19, as suggested by Ghani et al. [13]:

$$F_{it} = \frac{D_{it}}{D_{it} + R_{it}} \tag{3}$$

where D_{it} and R_{it} are the cumulative daily numbers of deaths and recoveries in the region i (from 1 to 21) at a given time t (from 1 to 70). The indicator does not disentangles the fatality ratios for the hospitalised and the non-hospitalised patients [13].

We model the virulence (i.e., the deadliness associated with SARS-CoV-2[1]), paying attention to the healthcare system management. In line with Nixon and Ulmann [24], and Reibling [29], we consider health outcomes as outputs of the healthcare systems, depending on the management of inputs (e.g., medical care resources). We control for social factors [29]:

$$F_{it} = \lambda + \boldsymbol{\lambda}_i + \boldsymbol{\lambda}_t + \boldsymbol{\psi}\boldsymbol{M}_{it} + \omega\Delta G_{it} + \nu_{it} \tag{4}$$

where the term $\boldsymbol{M}_{it}$ collects variables related to the epidemic management and ΔG_{it} controls for the growth of contagions, that may

[1] COVID-19 is the main cause of death in infected patients. The analysis of the medical records conducted by National Institute of Statistics on a sample of 4,942 infected patients shows that COVID-19 is the underlying cause of death in 89% of cases and a contributory cause or deaths in the remaining 11% of cases (National Institute of Statistics, 2020). Before the COVID-19 pandemic, among infectious diseases, seasonal influenza is the third leading cause of death in Italy and may cause from 250,000 to 500,000 deaths worldwide [4].

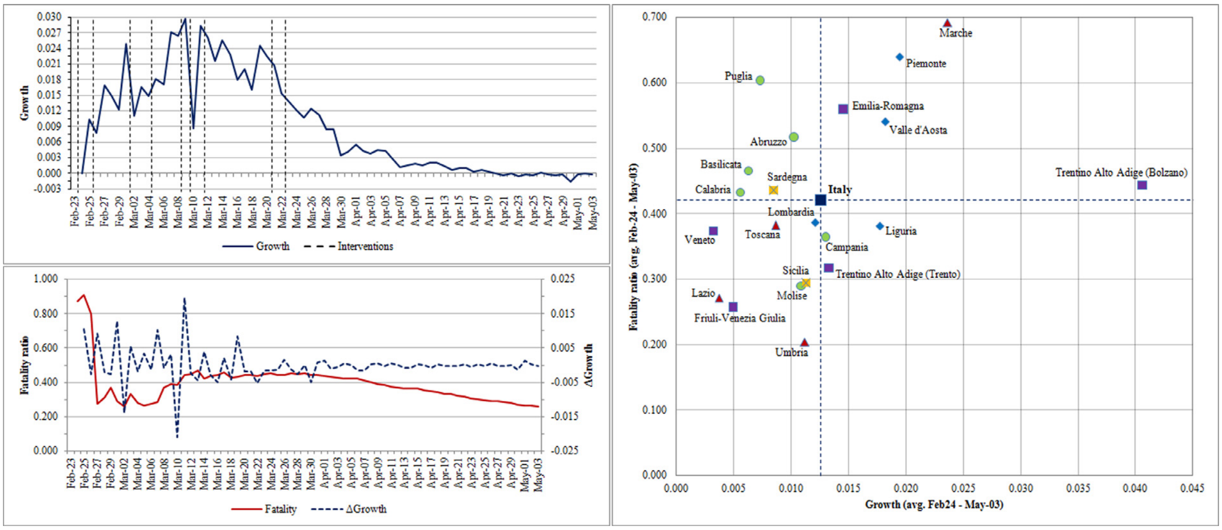

Fig. 1. Daily evolution of COVID-19 contagion and fatality (left panels) and positioning of Italian regions (right panel).

challenge the efficiency of the healthcare systems in managing epidemics [18]. The vector $\boldsymbol{M}_{it}$ includes the number of swabs per total population, the number of patients hospitalised for COVID-19 over the number of swabs, the number of patients confined with COVID-19 symptoms over the number of swabs. These variables explain the time-varying regional differences of fatality rates. . We control for the regional unobserved heterogeneity ($\boldsymbol{\lambda}_i$) and for time effects ($\boldsymbol{\lambda}_t$). Our estimates, through least squares, report standard errors geographically clustered.

The robustness of our findings is tested with different sets of controls: region-specific time-invariant determinants such as the percentage of hospital beds in intensive care wards, the percentage of hospital beds in infectious disease wards, the number of physicians per total hospital beds, the health expenditure per total population, in log We also control for life-style (i.e. percentage of smokers over total population) and environmental characteristics (i.e. percentage of males over total population, old-age rate, death rate)..

3.3. Data and descriptive analysis

The daily evolution of the first wave of the COVID-19 epidemic in Italy, in terms of contagion and fatality rates is described in the Appendix (section A.4). We cover the period from February 24, 2020 (when the first COVID-19 case was detected in Italy) to May 3, 2020 (the last day of lockdown in Italy). In order to compute G_{it} (see Eq. (1)) and F_{it} (see Eq. (3)), we collected from the Italian Department of Civil Protection[2] the region-specific daily data on the number of new infected patients, swabs, deaths and recoveries.

When the growth in contagions approached zero, the fatality ratio started to decline (Fig. 1, left downward panel): this event occurred about three weeks after the implementation of very restrictive interventions, on March 22 (Fig. 1, left upward panel).

We collected information on policy interventions, whose timeline is reported in Fig. 1 (left upward panel), from the Decrees of the President of the Council of Ministers (named DPCM) which are published on the Italian Official Gazette and on the official website of the Italian Government. Italy has implemented more and more stringent measures, reaching the full lockdown within two weeks since the establishment, on February 23, of the first "red area" in some municipalities of the Lodi and Padova provinces, respectively in Lombardia and Veneto. Sporting events started to be suspended on February 25, followed by teaching, wellness, and fitness activities, on March 1. These measures have been extended to all regions on March 4. In addition, the disinfection of public transports became compulsory since March 1. On March 8 several new "red areas" were identified in Lombardia, Emilia-Romagna, Piemonte and Veneto. The DPCM dated March 9 has extended the lockdown to all Italian regions. Further measures of social distancing imposed the closure of business (March 11), parks (March 20), and industries (March 22) in all regions. The DPCM dated April 26 has fixed on May 4 the starting date for the "phase 2″, the progressive reopening of selected activities. A detailed description of policy interventions is available in the section A.5 of the Appendix.

Source: elaboration on data of the Italian Department of Civil Protection.

Notes: In the left upward panel, policy interventions (dashed lines) plan partial lockdown in Lombardia and Veneto regions (Feb-23); suspension of events in Emilia-Romagna, Friuli-Venezia Giulia, Liguria, Lombardia, Piemonte, Veneto regions (Feb-25); suspension of events and teaching activities in Emilia-Romagna, Liguria, Lombardia, Marche, Veneto regions, closure of fitness and wellness in Emilia-Romagna and Lombardia regions, disinfection of public transports in all regions (Mar-01); suspension of events and teaching activities in all regions (Mar-04); partial lockdown in Emilia-Romagna, Lombardia, Marche, Piemonte, Veneto regions (Mar-08); lockdown in all regions (Mar-09); closure of business retails in all regions (Mar-11); closure of parks in all regions (Mar-20); closures of industries in all regions (Mar-22). In the right panel, north-western regions are in blue, north-eastern regions are in violet, central regions are in red, southern regions are in green, main islands are in orange. The positioning of regions is determined according to the average COVID-19 contagion and fatality over the period Feb-24 – May-03.

The right panel of Fig. 1 clusters regions according to the first-wave contagions and fatality rates. The average daily growth rate of new infected patients is 1.3%; the average fatality rate is 42.2%. The Northern regions, and the Marche region, have been the most affected in terms of contagions and fatality rates: the highest fatality has been observed in Marche (69.3%); the contagions grew the most in Trentino Alto Adige. The Southern regions reported high fatality rates, despite a lower diffusion of contagions: Puglia had an average 0.7% growth in contagions, coupled with a 60.4% fatal-

[2] Data available at: https://github.com/pcm-dpc/COVID-19.

Table 1
Descriptive statistics of key variables.

Variable	Type	Mean	Std. Dev.	Min	Max
Growth of contagions	Continuous	0.01	0.05	−0.20	1.00
Fatality rate	Continuous	0.42	0.25	0.00	1.00
Lockdown	Continuous	0.79	0.40	0	1
Social distancing (events, teaching activities)	Continuous	0.91	0.29	0	1
Social distancing (fitness and wellness)	Dummy	0.78	0.42	0	1
Social distancing (retail business)	Dummy	0.76	0.42	0	1
Social distancing (parks)	Dummy	0.64	0.48	0	1
Social distancing (industries)	Dummy	0.60	0.49	0	1
Disinfection of public transports	Dummy	0.95	0.22	0	1
Swabs per population	Continuous	1.23	1.57	0.00	8.33
Hospitalised per swabs	Continuous	0.04	0.06	0.00	1.00
Confined with symptoms per swabs	Continuous	0.07	0.06	0.00	0.84

Table 2
Policy interventions and COVID-19 contagions.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Lockdown	−0.0125***	−0.0127***	−0.0141*	−0.0120***	−0.0121***	−0.0115
	(0.0027)	(0.0027)	(0.0082)	(0.0029)	(0.0029)	(0.0074)
Social distancing (events, teaching activities)	0.0027	0.0026	0.0039	0.0013	0.0012	0.0019
	(0.0066)	(0.0065)	(0.0097)	(0.0073)	(0.0073)	(0.0104)
Social distancing (fitness and wellness)	0.0026	0.0025	0.0050	0.0026	0.0025	0.0050
	(0.0054)	(0.0054)	(0.0044)	(0.0054)	(0.0054)	(0.0044)
Social distancing (retail business)	−0.0058	−0.0055	−0.0189	−0.0057	−0.0055	−0.0186
	(0.0047)	(0.0048)	(0.0118)	(0.0048)	(0.0048)	(0.0115)
Social distancing (parks)	−0.0029***	−0.0020*	0.0031**	−0.0033***	−0.0025**	0.0018
	(0.0011)	(0.0012)	(0.0015)	(0.0010)	(0.0011)	(0.0012)
Social distancing (industries)	−0.0049***	−0.0051***	−0.0080***	−0.0046***	−0.0048***	−0.0069***
	(0.0011)	(0.0011)	(0.0011)	(0.0012)	(0.0012)	(0.0008)
Disinfection of public transports	−0.0235	−0.0236	−0.0233	−0.0226	−0.0227	−0.0227
	(0.0201)	(0.0201)	(0.0173)	(0.0199)	(0.0199)	(0.0173)
Recovery (delta)	−0.00001**	−0.00001**	−0.00001**	−0.00001**	−0.00001***	−0.00001***
	(0.000005)	(0.000005)	(0.000005)	(0.000005)	(0.000005)	(0.000004)
Regional control factors	Yes	Yes	Yes	No	No	No
Region dummies	No	No	No	Yes	Yes	Yes
Time trend	No	Yes	No	No	Yes	No
Time dummies	No	No	Yes	No	No	Yes
Observations	1134	1134	1134	1134	1134	1134
Number of ID	21	21	21	21	21	21
R-squared						
within	0.1757	0.1758	0.1952	0.1756	0.1757	0.1951
between	0.4920	0.4940	0.5018	0.8470	0.8473	0.8449
overall	0.1876	0.1877	0.2067	0.2009	0.2010	0.2196

Notes: The dependent variable is the growth of contagions computed as in Eq. (1). Policy variables are observed with a 14-days delay. Specifications (1), (2), (3) control for observed heterogeneity across regions (i.e., PM10 levels, density, distance from main locus); specifications (4), (5), (6) control for unobserved heterogeneity across regions (i.e., region dummies). Time trend included in specifications (2) and (5); time dummies included in specifications (3) and (6). ID are regions/autonomous provinces (Trentino-Alto Adige region divided in Provincia Autonoma di Bolzano and Provincia Autonoma di Trento). Robust standard errors, in parentheses, are clustered at geographical area level.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

ity rate, followed by Abruzzo (1.0% and 51.7%), Basilicata (0.6% and 46.6%) and Calabria (0.6% and 43.3%).

To examine the effects of the healthcare systems, we control for several factors, collecting, from the Italian Department of Civil Protection, the daily region-specific data on the number of swabs per popuation[3] (2.7 in Trentino-Alto Adige and Veneto, 1.9 in Valle d'Aosta, 1.8 in Friuli-Venezia Giulia, 1.4 in Emilia-Romagna and Lombardia as compared to 0.4 in Campania, 0.5 in Puglia, Sicilia and Sardegna), patients hospitalised for COVID-19[4] (about 4%) or confined with COVID-19 symptoms (about 7%) (*cfr.*Table 1).

[3] Information on the number of swabs, collected from the Department of Civil Protection, are based on data from the National Institute of Health and Regional Department of Health. Data include also swabs repeated on the same person in different time periods.

[4] The analysis of medical records conducted by National Institute of Health on a sample of about 100,000 patients hospitalised for COVID-19 shows that about 90% of hospitalisations have been caused by the COVID-19.

4. Results and discussion

4.1. The effects of policy interventions on contagions

The results of our estimates on the contagions model are reported in Table 2. Findings are robust to specifications with different variables to control for observed (columns 1, 2, 3 of Table 2) and unobserved (columns 4, 5, 6 of Table 2) heterogeneities. In line with Acemoglu et al. [1], the greater the number of new recovered patients, the lower the number of new contagions.

The measures implemented to contain contagions (lockdown and the closure of parks and industries) are negatively correlated with the number of new infected patients.

Our results on the lockdown are in line with Fang et al. [7], who found the same for the COVID epidemic in Wuhan. The daily growth of COVID-19 cases has been reduced by 1% due to the introduction of lockdowns. We found that the effects are evident about 14 days after the entry into force of the restriction, as also

Table 3
Managerial choices and variation in COVID-19 fatality.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Swabs per population	−0.0258**	−0.0260**	−0.0153	−0.0303***	−0.0305***	−0.0051
	(0.0119)	(0.0120)	(0.0147)	(0.0113)	(0.0116)	(0.0162)
Hospitalised per swabs	1.7091***	1.7070***	1.3768***	1.9836***	1.7984***	1.1637*
	(0.4354)	(0.4245)	(0.4892)	(0.3312)	(0.3457)	(0.6342)
Confined with symptoms per swabs	1.9368***	1.9399***	1.6377***	1.6144**	1.6394**	1.3010***
	(0.5944)	(0.6030)	(0.3429)	(0.6432)	(0.6408)	(0.3687)
Growth of contagions (delta)	0.0164	0.0162	0.0184	0.0187	0.0170	0.0209
	(0.0293)	(0.0290)	(0.0142)	(0.0281)	(0.0287)	(0.0159)
Regional control factors	Yes	Yes	Yes	No	No	No
Region dummies	No	No	No	Yes	Yes	Yes
Time trend	No	Yes	No	No	Yes	No
Time dummies	No	No	Yes	No	No	Yes
Observations	1083	1083	1083	1083	1083	1083
Number of ID	21	21	21	21	21	21
R-squared						
within	0.5774	0.5776	0.5890	0.5700	0.5734	0.5844
between	0.5155	0.5156	0.5264	0.8689	0.8715	0.9167
overall	0.5567	0.5568	0.5726	0.6460	0.6493	0.6711

Notes: The dependent variable is the fatality ratio computed as in Eq. (3). Growth of contagions (delta) is observed with a 14-days delay. Specifications (1), (2), (3) control for observed heterogeneity across regions (i.e., hospital beds in intensive care wards, hospital beds in infectious diseases wards, physicians per total hospital beds, healthcare expenditure per population, percentage of males, old-age rate, percentage of smokers, death rate); specifications (4), (5), (6) control for unobserved heterogeneity across regions (i.e., region dummies). Time trend included in specifications (2) and (5); time dummies included in specifications (3) and (6). ID are regions/autonomous provinces (Trentino-Alto Adige region divided in Provincia Autonoma di Bolzano and Provincia Autonoma di Trento). Robust standard errors, in parentheses, are clustered at geographical area level.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

suggested by Becchetti et al. [2]. The closure of industries contributed to a 0.5–0.8% reduction in the daily growth of COVID-19 cases, results that are in line with Milne et al. [23], who conclude that workplace nonattendance reduced contagions during the epidemic. The Singapore's experiences with SARS and H1NI suggest that the social distancing measures are effective only when more partners work together; single or unilateral interventions are less effective than multiple containment measures (Bell (2004; [21]). We confirm these evidences for the COVID-19 pandemic.

We disentangle the impacts of non-pharmaceutical measures using different lags: i.e., 0-days, 7-days, and 14-days of delay. The results of this sensitivity analysis, omitted for brevity and reported in the Appendix (section A.6), show that a higher number of days of delay corresponds to a more robust effect. The effects of policy interventions are effective about 14-days later (Table 2), due to the incubation period of the virus, as also documented by Goodman-Bacon and Marcus [14] and by Flaxman et al. [10]. Lauer et al. [22],report an incubation period for the SARS-CoV-2 of 5.1 days, with detection of symptoms within 11.5 days of infection in 97.5% of cases, and within 14 days for the remaining cases. According to our analysis, the different timing in the implementation of the policy interventions across regions have affected the spread of contagions [14]. The results are robust to several sensitivity analyses to control for macro-regional heterogeneities, differences in income levels, and potential neighbor-contagion effects (results, omitted for brevity, are reported in the section A.7 of the Appendix).

4.2. The effects of epidemic management on fatality ratios

We evaluated how the management of the healthcare systems influenced the fatality ratios. Our findings (Table 3) are robust to different specifications, controlling for regional characteristics, time effects, and for alternative control factors.

We find that the larger the number of infected patients hospitalised for COVID-19 or confined with COVID-19 symptoms, the higher the fatality ratios. The rationale is that a pressing demand on the healthcare system (i.e. peak load hospitalisations and critical care requirements) the heavier the healthcare burden [18], and the lower the efficiency [28]. Our results are also consistent with Zhang et al. [32], who found similar evidence in the early stage of the outbreak in Wuhan in China, due to the shortage of beds.

An opposite effect is found for the number of swabs per population. The greater the numbers of swabs per population, the lower the fatality ratios. As suggested in Zhang et al. [32], improved and optimised diagnoses (via swabs) are crucial for saving severe and critical patients.

Our results are robust to the inclusion of control factors proxying healthcare inputs (Table 3, columns 1, 2, 3) or the addition of new intensive care units to face the epidemic (see section A.7 of the Appendix). Our findings are also robust in sensitivity analyses that control for macro-region heterogeneities, differences in income levels, and air pollution (results, omitted for brevity, are reported in the section A.7 of the Appendix).

5. Discussion

We show that the effects of the interventions (e.g., lockdowns) are relevant only after a couple of weeks from their implementation. However, the anticipation (through announcements) of new closures (e.g. retail business and parks) has rapid effects. Put differently, anticipated policy interventions tend impact prior of their implementation. As for the closure of industries and parks, measures that have been introduced after other stringent measures (e.g. lockdowns), the effects are likely to be due to a synergic effect with the previously adopted policies, as suggested by German et al. [12] and Hatchett et al. [15]. Thus combining different social distancing measures, in a holistic approach, rather than relying on a single action, seem an effective approach.

The delayed effects of the measures suggest the need of acting timely and of a maintaining the containment measures for a longer time before ascertaining their effectiveness [10]. Policy decisions should be not only timely, but also “forward-looking”. Moreover, attention should be also paid to the communication of planned policy interventions, in order to amplify their effects.

Consistently with the literature, we also found that a proper healthcare system management of epidemics may sensibly reduce the mortality rates (e.g., [24]). In our specific analysis we show that an advanced diagnosis would reduce the fatality ratio, that may be further reduced by specific treatment strategies (e.g. intensive care units). The Italian healthcare system has been recently improved accordingly: on May 19, 2020, the Legislation Decree no. 34/2020 "Decreto Rilancio" has largely increased the intensive care units in orderto reduce the pressure on the healthcare system.

In short, we conclude that the pandemic may be slowed down through a synergic approach, made of several interventions to increase the social distance, and to avoid contacts. In addition. a robust healthcare system may help mitigating the negative effects, but its proper management is crucial to decrease the number of deaths.

Our analysis is not exempt from limitations. First, the quality of data is affected by different registration approaches at the regional level and across time. For instance, the swabs have been often performed on patients with severe symptoms and with previous contacts with positive cases, but not on the asymptomatic but potential positive patients. This may lead to underestimate the COVID-19 cases. This concern has been partially mitigated by the normalization (through the number of swabs) we have performed on the dependent variable of the model of contagion. On the other hand, relying on the official data makes our analysis reliable and comparable with the existing studies.

Second, our empirical models do not control for potential effects due to intra-regional and inter-regional mobility. These dynamics, partially controlled by regional, macro-regional, and time fixed effects, are beyond the scope of this analysis and left for future research.

Third, our empirical models has a strong validity in detecting correlations between contagions, fatality, policy interventions and management strategies, but should be cautiously taken before concluding on causality relationships. Future research should investigate these dynamics with counterfactuals, and experimental methods, if feasible.

6. Conclusions

The rapid evolution of the COVID-19 pandemic reached more than 200 countries, and called for a timely response to slow down the number of contagions and deaths [11]. Policymakers have implemented a wide range of non-pharmaceutical interventions, such as lockdown and social distancing measures, to mitigate the spread of the pandemic [14] and the burdens on healthcare systems [9]. Efficient responses of the healthcare systems are crucial to handle the health crisis and mitigate the severity of health outcomes [27], thus measuring the effectiveness of the policy interventions is of utmost importance to learn lessons from the COVID-19 pandemic. We derive a lesson from the first-wave epidemic evolution of COVID-19 in Italy.

We found that the sequential introduction of measures to increase social distance has been associated with an important decrease in the daily number of new infected patients. Our findings, in line with previous studies on other pandemics (e.g., Bell, 2004; [9]) and on the COVID-19 (e.g., [2, 7]) suggest that the impact of lockdowns is more effective if coupled with other containment measures.

We also show that a robust and well managed healthcare system is crucial for containing the negative health outcomes associated with COVID-19.

The preparedness of the healthcare system does not only depend on the resources availability, but also by the capability of promptly and efficiently react to in the insurgence of health crises. In other terms, the resilience of the system heavily depends on the management of resources. In addition, it is advisable for policymakers to engage in synergic actions to develop a coherent, unified strategy to mitigate both the transmission of contagions and the cumulative number of deaths associated with the health crisis.

Declarations of Competing Interest

None.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.healthpol.2021.05.014.

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