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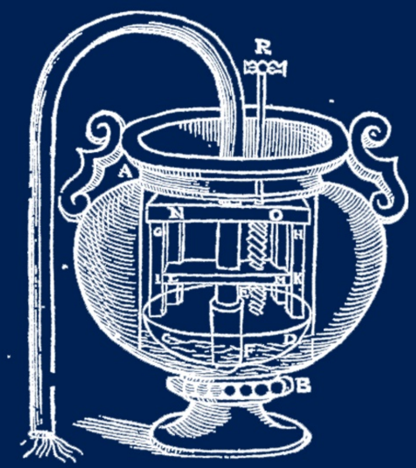
Different waves and different policy interventions in 2020 Covid-19 in Italy: did they bring different results?



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Different waves and different policy interventions in 2020 Covid-19 in Italy: did they bring different results?*

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ABSTRACT
Covid-19 pandemic hit very harshly Italy in two waves: the first can be temporally placed in spring and the second between autumn and winter. Data shows some relevant differences among the two phases, in particular, the first wave caused less infection but with a higher lethality rate. These differences in epidemic and social conditions in the two phases suggested a change in the strategy of containment measures: stricter and homogeneous in the first wave, flexible and diversified in the second wave. The interrupted analysis applied to daily data of new infected shows positive results for both interventions in flattening the infection curve. Both policies achieved almost the same percentage of positives cases avoided. For this reason, these measures seem rightly tuned, in both cases, to the specific epidemic and social conditions of each wave.

KEYWORDS: restriction measures, health policy evaluation, interrupted time series, Covid-19.

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CONTENTS

1. INTRODUCTION

In 2020 Italy suffered the Coronavirus disease (Covid-19) as the first country in Europe with a rapid increase of cases starting on 21 February. The spread of the pandemic runs out its effect in June but, after a summer of remission, in September a second wave began.

These two periods will be analysed and compared, referring to the rich literature which describes punctually the evolution of this disease in terms of new infected and the shape of the curve which data design.

Each curve had a different pace since in the first wave the peak of new infected was reached in 27 days, whereas in the second it took 61 days from the beginning. However, looking either at the infection curve and at the measures put in place by institutions is reasonable to consider an equal period for both waves.

The objective of this paper is to evaluate if, ceteris paribus, interventions could have helped to contain the virus and to reduce the number of new infected. This is most interesting since the measure adopted present a different degree of restriction which underpin a radically different approach to the disease due to the changes of the context both considering the healthcare system and social/political environment.

The method here applied is interrupted time series, where the break imposed by an external intervention concerns the time variable (Linden, 2015). The basic idea of this method is to compare the effective trend in post-treatment data with the hypothetic trend, which begins in pre-treatment and would have continued without interventions. In other words, the latter would be a control group created ad hoc to be compared with effective results post-intervention.

Given the awareness of the limits of this method, results give some hints on the possible contribution of different non-pharmaceutic measures used in each battle against this new virus.

2. COVID-19 WAVES IN ITALY IN 2020

In this section of the paper, a brief description of the two Covid-19 waves in Italy is presented, in order to look carefully at their characteristics, trying to sketch also the uneven contests where policy interventions were deployed.

As it is in Altems (2021) research, the two Covid-19 waves are here considered equivalent in terms of duration: 109 days each. Indeed, within this timeframe, both waves show the shape of positive cases as an expected Gaussian curve, with a final drastic reduction of the virus. Such a comparison, based on time series of the same length, is much more balanced and feasible.

Table 1 describes some basic information that seems useful for setting the main crucial points of the two waves, either in terms of schedule or in terms of quantitative measurement.

The point of beginning and end are not casual but represent some generally recognized milestones of the pandemic in Italy (Altems, 2021). The first wave occurred between February (24th) and June (11th), the second between September (14th) and December (31th). Each wave presents a different intervention timing. In the first wave, the relevant containment measure started 15 days after the pandemic beginning (March 9th), in the second wave containment action arrived (November 6th) 61 days after that which can be considered the first day.

The comparison of the quantitative dimensions of the infection reveals that the second wave of diffusion was greater, both for what concerns infected people and deaths.

However, a relevant difference to be considered regards the ratio of lethality, because this indicator shows that infection was much more dangerous for those who were infected in the first wave.

Table 1. Covid-19-19 first and second waves in Italy: main dates and quantities

	First wave	Second wave
Dates		
Starting day	24-February	14-September
Intervention day	09-March	06-November
Peak day (maxim. Contag.)	21-March	13-November
Final day	11-June	31-December
Main quantitative data		
Total positive	23.6134	1.822.841
Total deaths	34.167	38.549
Maximum average lethality	14,90%	1,90%

Source: Altems (2021) and Dipartimento della Protezione civile (2020).

Some relevant qualitative elements must be mentioned since they can help to better understand the nature of these two different phases of spreading and the different interventions adopted, beyond what the data indicate.

In the first wave, Italy was the first European country hit by the Covid-19 with a dramatic impact on the national health system that was unprepared to face such a subtle diffusion of a new virus. Nobody knew how to face this unprecedented situation and Covid-19 cases increased very rapidly. The spread of the infection in the first period was quite concentrated in some provinces of the northern regions and then touched the whole country, even though with an uneven degree of positivity and lethality. The pandemic was faced with a very strict lockdown for the whole country – basically a national "stay at home" rule – which was coupled with other non-pharmaceutical interventions, such as quarantine, aiming at a drastic reduction of mobility and social contacts (Chirico et al., 2021).

In the second wave, which started after the reopening of activities and public transports, a clearer perception of the new virus was widespread and a better knowledge of its behaviour and its consequences was accumulated by the healthcare system. Most of all, a different reaction was possible in the second wave thanks to the availability of masks, tests and essential clinical machines like ventilators, insufficient for the demand at the very beginning of Covid-19 diffusion. Better results in medical care were achieved in autumn for two main reasons: for the therapeutic experience gained by doctors, on one hand, and for the younger average age of patients, on the other hand (Borghesi et al., 2021). In the second wave, the virus was spread in the whole country, affecting southern regions and big cities more seriously than the first one. The new non-pharmaceutical interventions, required by data worsening, implemented a regional zone system containment based on a different level of risk among regions. Apart from the very basic measures valid for all countries – social distances and wearing masks – each region could adopt different dispositions on opening economic activities, schools, shops. This new kind of intervention in the second wave, more flexible and adaptable, showed a lesser stringency of restrictions on mobility concerning the policy intervention of the first wave (Conteduca, 2021).

3. Method

The method applied do daily new positive data (Dipartimento Protezione Civile, 2020) in this paper is interrupted time series, as in other researches in this field (Turner et al., 2019; Siedner et al., 2020; Saki et al., 2021; Soriano et al., 2021).

Such a wide application of interrupted time series seems to be due to the appeal of nonrandomized quasi-experimental design for policy evaluation given the impossibility of impracticability of randomized controlled trials. In particular, interrupted time series has been revealed to be the "strongest quasi 1 experimental design to evaluate longitudinal effects of such time delimited intervention" (Wagner et al., 2002, p. 299).

An alternative method of analysis of interrupted time series is based on the Auto-Regressive Integrated Moving Average (ARIMA) model (Box & Tiao, 1975). It is a very effective model, but used more for prediction than for evaluation and not particularly widespread for healthcare evaluation (Nosvelli & Musolesi, 2009; Lagarde, 2011).

Interrupted time series applied to the evaluation of policies adopted to face the Covid-19 pandemic brought relevant results in different applications in different countries. Molefi et al. (2020) found good results for the geographically concentrated and strict stay-at-home lockdown in China. Siedner et al. (2020) evaluated the impact of social distancing at the State level in the USA, finding a substantial decrease in epidemic growth. In a study on Iran, Saki et al. (2020) showed good results in reducing the slope of cases both from social distancing and from mandatory use of masks. These results were confirmed by the study on 28 European countries where beneficial effects of social distancing emerge clearly (Vokó and Pitter, 2020).

This method starts from the definition of a point in time of external intervention which is a break of time series typically due to a policy or a modification in strategy or therapy. The intervention could affect the series considered – in this paper the daily number of new Covid-19 positive – causing change concerning the pre-intervention pattern (Ramsay et al., 2003).

Two basic parameters define the segments of a time series which are before and after the date of intervention break: the level and the trend (Wagner et al., 2002). The first is the intercept which measures the base level at the starting point of each segment; the latter is the slope which represents the rate of change along each segment. Pre-Vs post-intervention change of the level denotes the sudden effect of the intervention, whereas pre Vs post change in trend is a gradual modification that comes out progressively along the segment (Rodrigues, 2020).

The regression specification is considered in a linear form, as it is in Lagarde (2012).

$$Y_t = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} * \text{time} + \boldsymbol{\beta_2} * \text{intervention} + \boldsymbol{\beta_3} * \text{postslope} + \varepsilon_t \tag{1}$$

Y_t is the output at time t and intervention is a dummy variable with 1 for the post-intervention. The model considers the following specification: $\boldsymbol{\beta_0}$ estimates the level at the beginning of the period before the intervention (time 0); $\boldsymbol{\beta_1}$ estimates the trend or structural output growth rate in the pre-intervention period; $\boldsymbol{\beta_2}$ estimates the change in output level immediately after the intervention; $\boldsymbol{\beta_3}$ estimates the slope or outcome growth rate in post-intervention period.

The error term, as usual, considers the variability non explained in the model.

Autocorrelation should be corrected in order to avoid an overestimation of the intervention effect. Prais-Winsten (1954) model is a generalized least-square method to estimate parameters with serially correlated errors.

Based on the estimation above, the policy effect could be calculated through the calculation of a hypothetical outcome that could have been without any intervention, which can be considered a counterfactual.

The comparison of post-intervention coefficients, obtained by the estimation of equation (1), with the counterfactual ones obtained on baseline level and the trend only, could give the net effect of the intervention.

The equation which should be estimated, without a standard control group, to calculate the counterfactual values is the following:

$$Y_{\text{without intervention}} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} * 109 \tag{2}$$

In this equation are included only the base level and the trend without intervention for the whole period of 109 days.

In order to obtain predicted outcomes derived by the intervention, the following equation is calculated:

$$Y_{\text{with intervention}} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} * 109 + \boldsymbol{\beta_2} * 1 + \boldsymbol{\beta_3} * \text{post-intervention period} \tag{3}$$

Two values should be added to equation (2) for obtaining equation (3) which evaluates the intervention output: the immediate impact after the introduction of the estimated value of policy intervention (***β₂*** * 1)[1] and the change in trend after the intervention (β_3 * post-intervention period). The former must be multiplied for the post-intervention period which lasted 94 days in the first wave and 55 days in the second wave.

The absolute net effect, which measures the impact of each policy, comes from the difference in the output obtained from estimations of equation (2) and (3), as follows.

Absolute net effect = $Y_{without\ intervention}$ and $Y_{with\ intervention}$

The relative effect of each policy can be obtained by calculating the relative change as follows:

Relative net effect = $((Y_{with\ intervention} - Y_{without\ intervention}) / Y_{without\ intervention}) * 100$

4. RESULTS

Tables 1 and 2 show the results of estimation of the two waves, based on the model (1), with the correction of autocorrelation.

Although the intercept of the first wave is not significant, the starting level of daily infected cases has a negative sign for both waves, since at the beginning of each period a decreasing daily number of new Covid-19 infected is detected.

The trend before the policy change was positive in both waves, showing how the day-by-day change of new infected was increasing.

A relevant difference in the two waves emerges from the estimation of the level right after the day of policy implementation. While the first wave shows a considerable increase in the level of positive, the second would show a drastic reduction of it but is not significant. The first intervention was adopted at the very beginning of the pandemic expansion, and it took some time before it became effective.

The trend estimated after the intervention shows a stable decrease of daily new cases: 154 in the first wave and 1.137 in the second one. This last result shows the positive impact of the policy in the two phases of diffusion of the pandemic. In both cases, policy intervention has been effectively reaching the objective of a considerable reduction of the infection.

Table 2. 2020 first wave of Covid-19 daily new positive in Italy: estimation results of a segmented linear regression model (corrected for first order autocorrelation)

Variables	*Coefficient*	*Standard error*	*f-statistics*	*P-value*
Intercetp β_0	-47.890	74.727	-0.640	0.523
Baseline trend β_1	87.033	17.103	5.090	0.000
Level change post-intervention β_2	2328.372	412.739	5.640	0.000
Trend change after intervention β_3	-154.196	18.099	-8.520	0.000

Table 3. 2020 second wave of Covid-19 daily new positive in Italy: estimation of a segmented linear regression model (corrected for first order autocorrelation)

Variables	*Coefficient*	*Standard error*	*f-statistics*	*P-value*
Intercetp β_0	-5468.912	1467.049	-3.730	0.000
Baseline trend β_1	525.175	52.151	10.070	0.000
Level change post-intervention β_2	-3787.269	3496.552	-1.080	0.281
Trend change after intervention β_3	-1137.400	114.992	-9.890	0.000

[1] The estimated value after the intervention is multiplied by one in order to maintain it unchanged in the equation.

From the estimated coefficient presented in tables 1 and 2, the absolute and relative net effects are derived according to the comparison of results with intervention to those results that would be reached without any policy.

With the introduction of containment policies in both waves, a reduction of new positive is achieved respect to what could have been without any policy, as many other researchers confirm (Tobías, 2020). The quantitative dimensions are different but the relative effects are almost equal, suggesting that, although operating in the different conditions, the policies adopted in the two waves reached quite similar results. According to our results in both waves, 128%-129% of infected have been saved avoided.

Table 4. Absolute and relative net effects in 2020 Covid-19-19 waves - Italy

	First wave	**Second wave**
Absolute net effect	-12.165	-66.322
Relative net effect	129%	128%

In figures 1 and 2 results of time-interrupted estimation of the two waves are depicted. Some point deserves to be mentioned.

Firstly, it emerges very clearly time unbalance in the first wave, where the intervention is quite close to the beginning of the pandemic, whereas in the second wave the comparison between pre and post-intervention seems quite balanced.

Secondly, in the first wave, the spreading does not stop after the intervention on 9th march or a few days later, but the number of infected keeps increasing for some days. This is clear looking at effective observations and predicted ones, which begin to decrease right after the intervention day. On the other side, in the second wave intervention almost corresponds with the maximum point of the curve when effective and predicted observations begin both to decline.

Lastly, the distribution of actual Vs predicted observations shows that in the second wave a lesser uniform reaction to intervention than in the first wave (Figure 2). In the first wave, effective observation moves more homogeneously around the prediction line (Figure 1). As has been already underlined, measures of containment in the second wave were much more heterogeneous among regions than in the first.

5. Conclusions

Covid-19 in Italy presented in 2020 two waves that were unbalanced in most respects, but, at the same time, were equated by the absence of a vaccine, which in 2021 changed radically the context with a drastic reduction of the degree of severity. Without this fundamental weapon against the virus, actions were based on non-pharmaceutical means for preventing the disease.

Two different strategies were applied, on one side based on the epidemic characteristics of the two waves, and on the other side in the light of the readiness of the healthcare systems.

In the first phase, policies implemented a strict lockdown oriented to an immediate block of the spreading surge, in a context of limited availability of medical equipment and partial knowledge of the disease. Such a national intervention, strongly shared by a common feeling, was adopted in the whole country shortly after the identification of the first case, in a phase of growing cases. It lasted for almost three months before reaching a condition safe enough for easing the restrictive measures.

In the second phase, a more modular and flexible strategy was preferred. Strong actions would have been more difficult to accept given the worsening degree of social cohesion, and several months of struggling against Covid-19 developed knowledge experience and therapeutic expertise. A territorial adaptation of policies to local needs was the core of the new strategy. It intervened in a phase of case reduction and lasted less than two months before the change of conditions.

Timing and strictness of measures represented crucial determinants for containment of pandemic which impacted severely in Italy and all over the world (Berardi et al., 2020). Results show that, ceteris paribus, both strategies succeeded and, according to our analysis, reduced drastically the number of infected also respect to the hypothetical control group obtained as if the intervention had not occurred.

The unexpected result comes from the relative index of net effect of interventions in the two waves, which is the ratio of predicted and counterfactual values. It reveals that both interventions obtained almost the same percentage of prevention of positives cases (128%-129%).

The main policy implication that can be drawn is that the two different strategies achieved the best results since they were efficiently tuned to the uneven epidemic and social conditions of each wave. The policy design has changed trying to control and, possibly, to anticipate the pandemic way of spreading.

Regardless of which measures should be chosen – social distancing, mandatory masks, tests, tracing – the good results obtained by each intervention seems to depend on the capacity of policymakers of being timely and focused on the characteristics of the pandemic.

The two interventions here analyzed were adopted with diverse timing and strategies, but they reached the same target within the same total timing: 109 days for both waves.

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7. APPENDIX

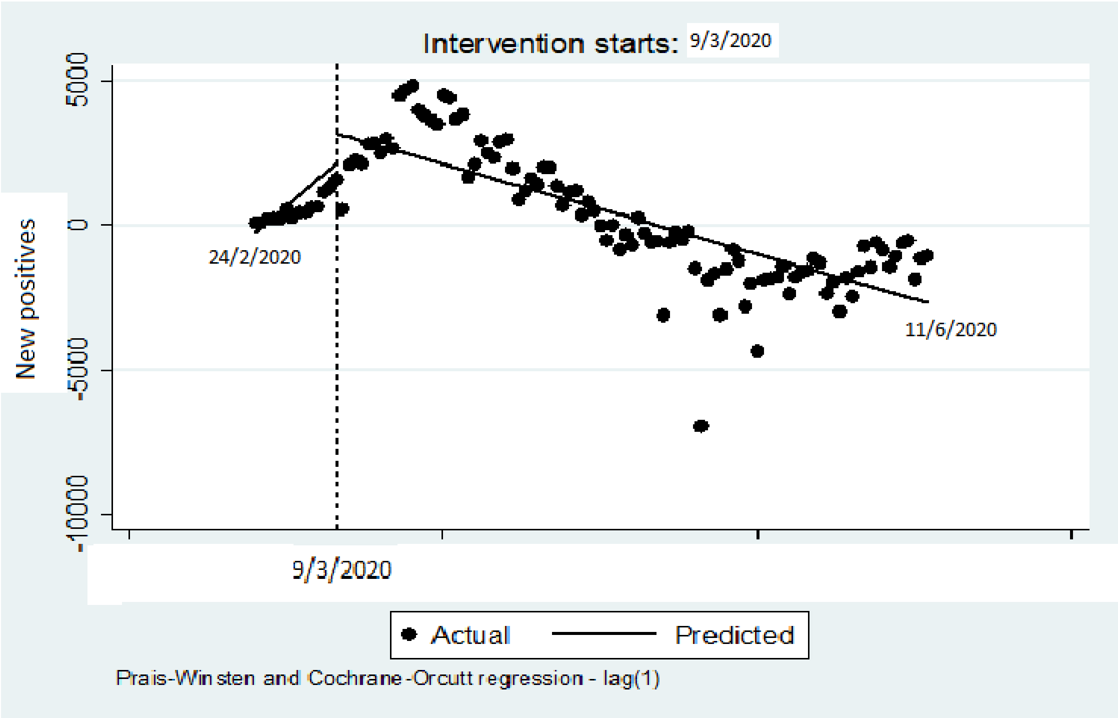

Figure 1. Interrupted time series estimation of daily new positives – First wave.

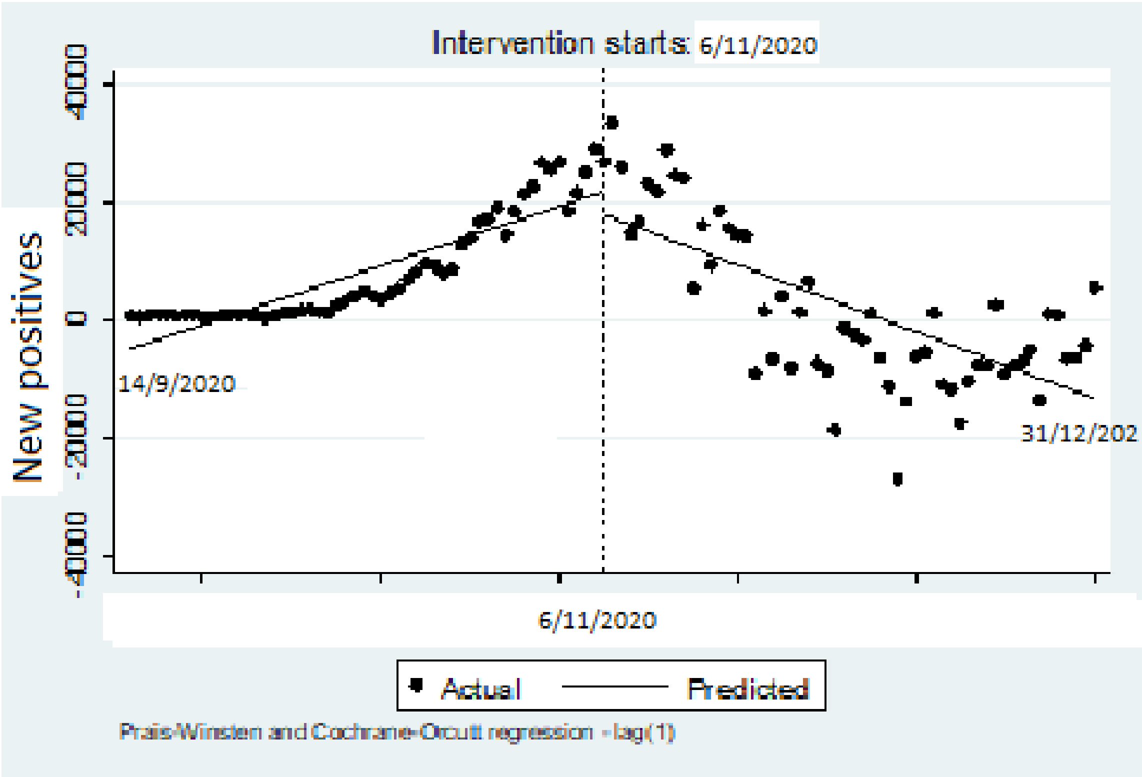

Figure 2. Interrupted time series estimation of daily new positives – Second wave.

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Covid-19 pandemic hit very harshly Italy in two waves: the first can be temporally placed in spring and the second between autumn and winter. Data shows some relevant differences among the two phases, in particular, the first wave caused less infection but with a higher lethality rate. These differences in epidemic and social conditions in the two phases suggested a change in the strategy of containment measures: stricter and homogeneous in the first wave, flexible and diversified in the second wave. The interrupted analysis applied to daily data of new infected shows positive results for both interventions in flattening the infection curve. Both policies achieved almost the same percentage of positives cases avoided. For this reason, these measures seem rightly tuned, in both cases, to the specific epidemic and social conditions of each wave.

CNR - Consiglio Nazionale delle Ricerche

IRCrES - Istituto di Ricerca sulla Crescita Economica Sostenibile