

# The impact of China's lockdown policy on the incidence of CoVID-19: An Interrupted time series analysis

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## Research Article

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# Abstract

## Background

Policy changes are often necessary to contain the detrimental impact of epidemics such as the coronavirus disease (COVID-19). China imposed strict restrictions on movement on January 23<sup>rd</sup>, 2020. Interrupted time series methods were used to study the impact of the lockdown on the incidence of COVID-19.

## Methods

The number of cases of COVID-19 reported daily from January 12<sup>th</sup> to March 30<sup>th</sup>, 2020 were extracted from the World Health Organization (WHO) COVID-19 dashboard ArcGIS® and matched to China's projected population of 1 408 526 449 for 2020 in order to estimate daily incidences. Data were plotted to reflect daily incidences as data points in the series. A deferred interruption point of 6<sup>th</sup> February was used to allow a 14-day period of diffusion. The magnitude of change and linear trend analyses were evaluated using the *itsa* function with ordinary least-squares regression coefficients in Stata® yielding Newey-West standard errors.

## Results

Seventy-eight (78) daily incidence points were used for the analysis, with 11 (14.10%) before the intervention. There was a daily increase of 163 cases ( $\beta=1.16 \times 10^{-07}$ ,  $p=0.00$ ) in the pre-intervention period. Although there was no statistically significant drop in the number of cases reported daily in the immediate period following 6<sup>th</sup> February 2020 when compared to the counterfactual ( $p=0.832$ ), there was a 241 decrease ( $\beta=-1.71 \times 10^{-07}$ ,  $p=0.00$ ) in cases reported daily when comparing the pre-intervention and post-intervention periods. A deceleration of 78 (47%) cases reported daily.

## Conclusion

The lockdown policy managed to significantly decrease the incidence of CoVID-19 in China. Lockdown provides an effective means of curtailing the incidence of COVID-19.

## Introduction

The recognition of a possible outbreak followed the identification of a cluster of cases presenting with a rare type of pneumonia<sup>(1)</sup>. These cases had both epidemiological and geographical ties to the Huanan seafood market in Wuhan, Hubei province, China<sup>(2,3)</sup>. Samples from these patients later revealed a novel type of coronavirus known as SARS COV-2<sup>(4)</sup>. A virus closely associated with those that cause Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS)<sup>(5,6)</sup>.

The few weeks that followed saw more cases being detected in the Hubei province, with Wuhan city having the highest number of cases<sup>(7)</sup>. The cumulative incidence increased exponentially daily reaching a few hundred in less than three weeks<sup>(8)</sup>. The situation needed containment especially with evidence of local transmission taking place in neighbouring provinces<sup>(9)</sup>.

On January 23<sup>rd</sup> 2020, the government of China imposed a lockdown on Hubei province in an effort to control the spread of the disease<sup>(10)</sup>. The lockdown resulted in restrictions on movement among residents of the province requiring all to stay indoors during this period. There were mixed reactions to this intervention with some labelling it as extreme especially as social support was not guaranteed<sup>(11,12)</sup>. Whilst China has recently reported a decline in the incidence of COVID-19, it is not clear what impact the lockdown has had on this decline.

This study sought to quantify the impact that China's lockdown policy had in reducing the incidence of COVID-19 using interrupted time-series methods.

## Methods

Cases of COVID-19 in China as reported daily were extracted from WHO's ArcGIS dashboard<sup>(13)</sup> for periods between January 12<sup>th</sup> and March 30<sup>th</sup> 2020. These figures were then matched to China's projected population for 2020, estimated at 1 408 526 449 according to the United Nations' population division<sup>(14)</sup>. The daily incidences were then calculated and used as data points in the time-series analysis. Additionally, because we did not expect the impact of the lockdown to start immediately, we carried the date intervention forward to 6<sup>th</sup> February; the length of time corresponding to the maximum incubation period of 14 days for someone who was exposed on or about 23<sup>rd</sup> January 2020.

Data were modelled as a single-group interrupted time-series analysis without a comparator using the *itsa* syntax in Stata®. The level of change and the trajectory of change following the intervention obtained via Ordinary Least-Squares (OLS) regression estimates were evaluated yielding  $\beta$ -coefficients and Newey-West standard errors. The Cumby-Huizinga test for serial autocorrelation using *actest*, *lags* in Stata<sup>(15,16)</sup> was employed as a post estimation command following the OLS regression.

## Results

Seventy-eight data points were used in the series with 11(14.10%) used in the pre-intervention period. There was a daily increase of 163 cases; 95% CI (110-216) in the pre-intervention period. When comparing the period immediately following 6<sup>th</sup> February 2020 and the counterfactual-what would have been had the policy not been passed, there was no statistically significant change in the numbers reported daily ( $p=0.832$ ). There was, however, an average decrease of 241 cases reported daily ( $p=0.000$ ) when comparing the pre-and post-intervention periods, resulting in an excess drop of 78 cases reported daily within the same time period

A post-estimation Cumby-Huizinga test, proved that serial correlation was significant up to 4 lags

## Discussion

Prior to this study, there was a question about the effectiveness of lockdown as a strategy for the containment of the spread of COVID-19<sup>(12)</sup>. The findings herein, reveal an increasing incidence of cases the pre-intervention period, perhaps as there were no restrictions on movement of people and goods across China before the lockdown. This significant increment of new cases daily would potentially have reached epic proportions, had the lockdown intervention not been instituted. This view is corroborated by the counterfactual scenario i.e. extending the pre-intervention trajectory beyond 6<sup>th</sup> February (Figure 1)

There was no statistically significant change in the incidence of cases on 6<sup>th</sup> February when compared to the counterfactual. These findings are not surprising as some tail-end diffusion could still be taking place. However, what was more interesting was an increased reduction in the daily incidence when comparing the pre and post-intervention period, resulting in a 47% net decline in daily incidence. This reduction thus indicates that the lockdown policy not only had a positive impact in reducing the incidence of COVID-19 but also resulted in an accelerated way of reversing the situation. The finding that China's COVID-19 incidence is decreasing is consistent with findings from other studies<sup>(17)</sup>. Of note is that the impact estimated herein is only conservative as there was a change in the case-definition of a COVID-19 case in mid-February in China from symptoms and a positive test to just symptoms<sup>(18)</sup>. An action that could result in the artefactual increment of COVID-19 cases reported.

Since we were evaluating the impact of a large-scale intervention using data before and after an intervention, interrupted time series methods were suitable for this purpose. These methods are powerful methods of high validity since they control for common threats of confounding which exist in other observational studies<sup>(19)</sup> therefore are a good compromise when it is not feasible or unethical to randomize units/subjects<sup>(20)</sup>. With a distinct time of intervention when the lockdown was announced and factoring in an estimated period of diffusion, we believe that enabled us to mimic the truth about the evolution of the disease in China. Furthermore, sensitivity analysis revealed the validity of our model up to 4 lags.

As more countries have started having cases of COVID-19, they will be looking for effective strategies to control the outbreak in their settings. This paper demonstrates the effectiveness a lockdown strategy and that it may be necessary to prevent more cases from occurring during an outbreak.

There are limitations that need noting in this study. First, we cannot rule-out the possibility of other interventions that could have contributed to the change, though so far, none have been published or reported. Secondly, we only had limited data points to model with before the intervention as it was only the beginning of the outbreak

## Conclusion

There is evidence that the lockdown policy introduced by China in containment of COVID-19 has completely reversed the incidence of COVID-19. The lockdown policy presents a viable option of decreasing the incidence of COVID-19.

## Declarations

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### Authorship

MM conceptualized and designed the study, acquired the data, and analyzed them. JTT, TP, SGH, TM, VS, YM and DJW assisted with the interpretation, drafting the article and revising the manuscript critically for important intellectual content. All authors approved the final version to be submitted

### Declarations

#### Ethics approval and consent to participate

No data at individual patient level were collected thus no ethical approval nor individual consent was applicable

#### Availability of data and materials

All data were publicly available

#### Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

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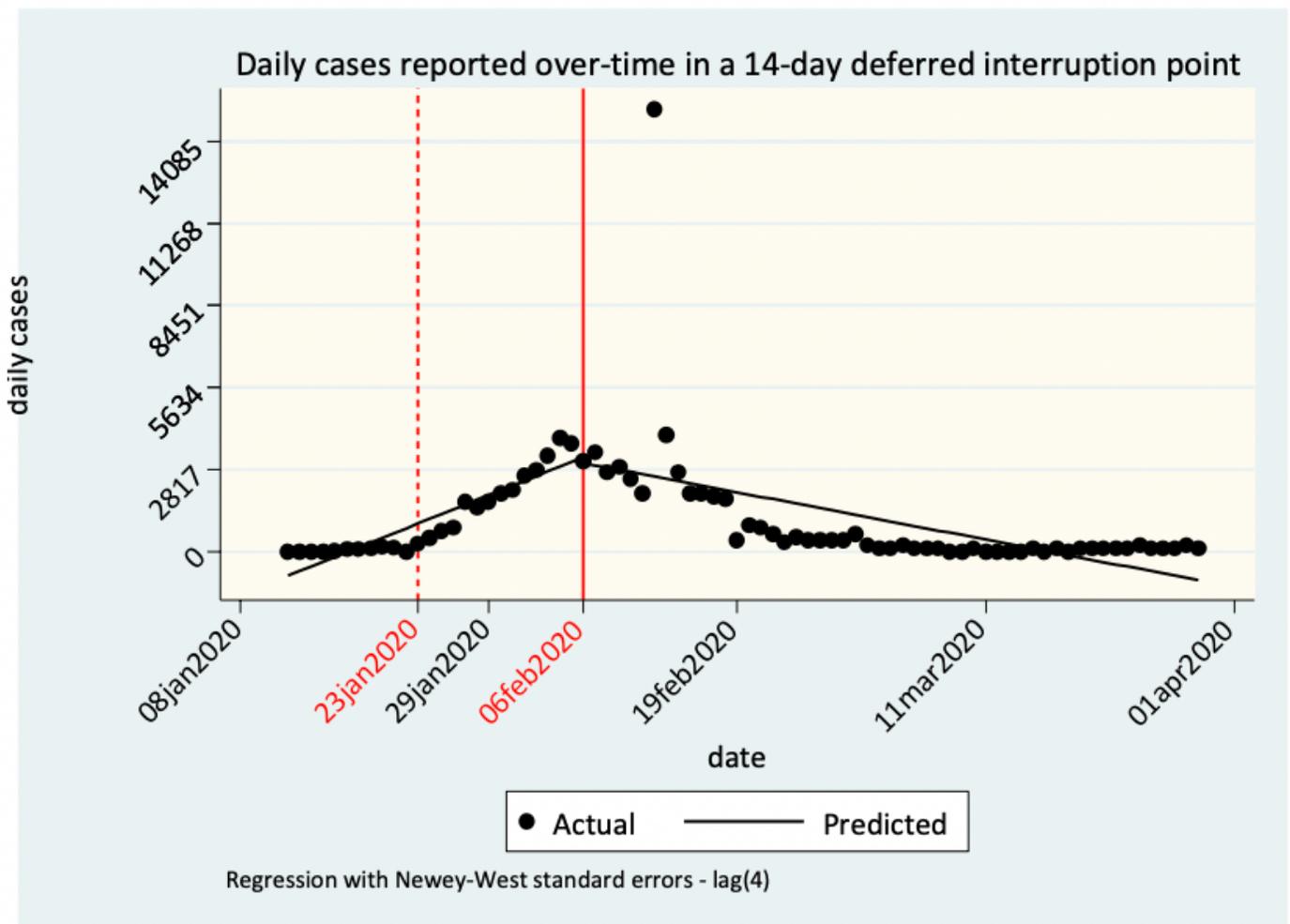
# Tables

Table 1: Interrupted time series ordinary least-squares regression output

	$\beta$ -coefficient	Std error	p-value	95% CI
Pre-intervention	1.16e-07	1.88e-08	0.000*	7.83e-08 - 1.53e-07
Immediately post intervention vs counterfactual				
	-1.47e-07	6.89e-07	0.832	-1.52e-06 -1.23e-06
Pre vs post intervention	-1.71e-07	2.58e-08	0.000*	-2.22e-07 -(-1.19e-07)

\*=statistically significant at  $p < 0.05$

# Figures



## Figure 1

Daily cases reported over time showing a 14-day deferred interruption point from 23 January to 6th February 2020