Forecasting the impact of the containment measures for COVID-19 in France, Italy, and Spain

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Research

Keywords: COVID-19, Forecasting, Italy, Spain, France

Posted Date: April 9th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-21774/v1>

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Abstract

Background: The Coronavirus disease of 2019 (COVID-19) is now a major challenge for healthcare systems in many countries, including some of the G20 countries like China, Italy and France. The purpose of this paper was to estimate how this disease could impact Italy, Spain and France, in comparison to China, based on the timing of their first response to the epidemic.

Methods: The study visually estimated when will the suppression strategies implemented in Italy, Spain and France would change the direction of the daily new infections curve. The study utilizes the publicly available data from the WHO website. The curve representing the response strategy from China was used as a visual reference in this case, assuming that the virus is impacting all populations in the same way, transmitted in similar rate, and the time needed from the implementation of the suppression strategies to the appearance of its impact would be identical in all countries. Then, the total number of cases and deaths will be estimated from the produced curve, based on the current death rate among all infected people in each country

Result: The response in the three countries was not as fast as it was in China. Based on the cumulative number of cases at the response time, France was the fastest responder to the epidemic; therefore, we expect it will be the least impacted among three countries with about 97,523 cases and 4,876 deaths. Followed by Spain with approximately 153,013 cases and 14,536 deaths, then Italy with 162,885 cases and 20,034 deaths. The peak date for the new confirmed cases was expected to be around April 2nd for Italy and Spain, and April 6th for France. Then, the new daily cases should be declining to around Zero by the end of April or the beginning of May.

Conclusion: Italy, followed by Spain, will be the most impacted countries in the European Union. Therefore, the support for Italy and Spain at this time is very needed, especially with medically trained personnel.

Introduction

The Coronavirus disease of 2019 (COVID-19) is now a major challenge for healthcare systems in many countries, including some of the G20 countries like China, Italy and France. As of 7th of April 2020, more than 1,211,000 people were infected by the virus and 67,594 died after suffering from severe acute respiratory syndrome (SARS) [1]. This massive spread of infections in such a short period reflects how contagious is this virus, that has started in China and affected most of the world.

Containment measures were taken by governments and healthcare systems around the world; some countries were stringent, proactive and quick, whereas others were lenient, reactive and slow in their response. Two main strategies were under investigation, the suppression and mitigation strategies. Suppression aims to slow the spread of the virus by interrupting its human-to-human transmission, whereas, mitigation aims to reduce the health impact of the COVID-19 epidemic without tackling the issue of the virus transmission, with the hope of a vaccine or a treatment will be available [2, 3].

China was the first to be impacted by the virus, and despite the paucity of knowledge about it and its consequences, their strict response bought the rest of the world time to understand the disease and set plans to contain the infection. China's suppression strategies included locking down cities with confirmed COVID-19 cases as well as implementing social distancing measures, such as closing schools and universities, and canceling all public gathering events; knowing that it was two days before the Chinese new year's celebrations [2]. All these measures were taken before they hit 500 confirmed cases. Whereas other countries preferred the mitigation strategy by educating the public about the virus hoping to slow down its transmission, waiting for a treatment or vaccine to become available or expecting people would develop herd immunity [2], as announced by the UK prime minister.

Multiple medications and vaccines are currently under investigation in an effort to mitigate the impact of this virus on the world. With all the limited information about the virus and the lack of effective treatment or vaccine, the purpose of this paper was to estimate how this virus could impact Italy, Spain and France, in comparison to China, based on the timing of their first response to the epidemic.

Methods

Knowing that COVID-19 is a contagious disease, and assuming it has a similar rate of transmission and compression after the implementation of the suppression strategies, and with all uncertainty and paucity of data, the study aims to use the curve representing the response strategy from China as a visual reference to visually estimate when will the suppression strategies implemented in Italy, Spain and France would change the direction of the daily new-infections curve. The study utilized the publicly available data from the daily situation reports on the World Health Organization (WHO) website [4].

After visually estimating the time and the point of inflection on the daily new-infections curve, we will predict the total number of cases and expected fatality assuming that healthcare systems in France, Italy, and Spain would contain the pressure by the cumulative number of cases and will continue to have the current rate of death. All visual data extrapolation and figures were done using Microsoft Excel 2016.

Results

After reporting a total of 310 confirmed cases of COVID-19 on January 23rd, almost 32 cases were detected on that day, China decided to lock down infected cities, banned social gathering, cancelled new year's celebrations, and suspended education. The new-infections curve continued to raise exponentially for 25 days, despite all suppressing strategies, until it reached the peak on February 17th with 19,461 new confirmed cases. After that the numbers of daily new-infections started to decline until March 19th when China reported zero new local cases. On March 22nd, after two months of lockdown, China started loosening its stringent measures. This information was presented on Fig. 1.

France, Italy, and Spain recorded their first confirmed cases of COVID-19 on January 25th, January 31st, and February 1st, respectively. Although the number of cases continued to raise, none of the three countries initiated any proactive suppression plans until France started suspending the entry through its borders and quarantining infected people on March 2nd, and on March 10th Italy and Spain implemented the same measures. France, Italy and Spain implemented full stringent measures by March 14th when they detected a total of 3,640, 12,462, and 4,231 confirmed cases of COVID-19, respectively (Figs. 2, 3, and 4.)

The data for France, Italy, and Spain were extrapolated assuming that the mitigation strategies will reduce the rate of daily confirmed cases, at the same pace in China. For France, we expected the peak of daily new-infections would be around April 5th with 5,000 cases. After that, we predict the number of daily new-infections will decline to be close to zero by the end of April or the beginning of May. If these assumptions were proven right by the end of April, then France would record about 97,523 cases in total cases, and 4,876 deaths.

For Italy and Spain, we expected both to reach their peak of new-infections around April 2nd with 10,000 and 8,000 cases, respectively. The numbers would then decline to be around zero by the end of April. If these assumptions were proven right, then Italy and Spain will record the highest number of total confirmed cases in Europe with 162,885 and 153,013, and deaths with 20,034 and 14,536, respectively. The total number of cases as of April 6th, and expected number of cases and deaths are presented in Table 1.

Table 1
Total and expected number of death and confirmed cases of COVID-19 as of April 6th

Country	Total number of confirmed cases	Total number of death cases	Current death rate	Expected total number of cases	Expected total death cases
World	1,210,956	67,594	5.6%	—	—
China	83,005	3,340	4.0%	—	—
France	69,607	8,064	5.0%	97,523	4,876
Italy	128,948	15,889	12.3%	162,885	20,034
Spain	130,759	12,418	9.5%	153,013	14,536

Discussion

The study was conducted to estimate the impact of implementing the suppression strategies on the daily and total number of expected COVID-19 cases in France, Italy, and Spain; these estimates were extrapolated based on the response to the suppression plans that were implemented in China, and proven to be effective. Our findings indicate that Italy is expected to be the most impacted among the four, followed by Spain, then France. This expected high impact in Italy is represented by the highest number of confirmed COVID-19 cases and death until the end of April.

The study estimated the number of COVID-19 cases in Italy to be more than twice the current number of cases in China, which will make Italy the most impacted country in Europe. Spain will be the second in Europe with more than 153,013 cases in total. Our estimates for France to the end of April was found to be between the middle range and the worst scenario (61,896–161,832) in Massonnaud et al. study, who have forecasted the number of cases to the middle of April [5]. This validate our method of visual extrapolation, and put our estimates between the middle range and worst scenario, closer to the middle range.

The need for ICU bed is one of the indicators for the readiness of healthcare systems in such crises. Based on the previous data from China, about 5% of all confirmed cases with COVID-19 needed to be admitted to intensive care units (ICU), and 2.3% needed to be on invasive mechanical ventilation [6]. Nevertheless, a study indicated that about 16% of patients in Lombardy, Italy needed to be admitted to the ICU [7], which is much more than what they have expected or planned for. Before the epidemic, there were about 5,090 ICU beds in Italy, which was then planned to be increased to about 9,000 beds [8]. Even with the most conservative estimates, this limited number of ICU beds facing the large expected number of cases, we do not expect the healthcare system and the healthcare workers in Italy to be able to withstand these large number of cases, and if not supported by all means, specially medically trained personnel, the system will collapse very soon. Moreover, we started to see the fatality and infections among healthcare workers as a result for this crises [9, 10], when we were about a week away from the expected peak of the curve for Spain. In France, the healthcare system had about 5,000 ICU beds initially, and they are working to increase it by about 4,000 units, to reach a total of about 9,000 units, in order to meet the upcoming needs [8]. Based on the previous information, our estimates suggest that the health care system in France will be able to sustain the current epidemic with the current support, which is similar to what Massonnaud et al. forecasted in the middle range scenario [5]. Spain had about 4,400 ICU beds before the epidemic, and they did not report plans to increase this number till the end of March. However, with the increased number of cases at the end of March, they started adding ICU beds in the beginning of April. Similar to Italy, we did not expect the health care system in Spain to withstand the upcoming large number of cases till the end of April, which will affect the healthcare workers and their patients. The signs of collapse for the healthcare system in Spain has already started to appear at the end of March, as more than 3,500 healthcare workers in Spain tested positive for COVID-19, which represent about 14% of all infected patients in Spain at that time [11]. Moreover, as the number of critical cases started to surge in Spain at the end of March, physicians in the ICU started to prioritize whom should be put in the ICU and on mechanical ventilation [12], that when Spain was about a week away from the expected peak for the new-infections curve.

Knowing all the previously discussed pressure on the healthcare systems in Italy and Spain, Italy and Spain are expected to lose more than 20,000 and 14,500 patients, respectively. While France is expected to lose about 5,000 patients, which is again between the middle range and the worst scenario (3,237–11,025) that were reported by Massonnaud et al [5]. However, if the healthcare systems in Italy and Spain collapse, then nobody can expect what will happen or even predict how the people in the countries would behave.

Based on the cumulative number of confirmed cases in the three countries, France was the fastest to react to the epidemic, as it reacted before their daily new confirmed cases hit the 1,000 cases mark, which we believe to be very critical in the progression of the transmission. Therefore, it would be the least impacted among the three. France reaction was not as fast as China, France had more than 3,500 confirmed cases when reacted whereas China had only 574 confirmed cases and had very limited information about COVID-19, compared to the rest of the world now. Nevertheless, we believe that China had more than that number at that time, but they have just started tracing and testing suspected cases which was then translated into a surge in the number of newly confirmed cases, which we took into consideration when extrapolating the curve.

With the limited evidence about the appropriate timing and duration for implementing any of the suppression strategies [13]. it was not easy for the decision makers in France, Italy, and Spain to decide when should they initiate any of these strategies, and for how long it should remain in place. Moreover, this difference in timing for implementing different suppression strategies was one of the

major reasons behind the variation in the number of current and expected cases of COVID-19 in these countries. Furthermore, the number of confirmed cases when initiating the suppression strategies have impacted our estimates, and we suggest that it should be taken into consideration when deciding to make such an action in the future. However, more research is needed to find when should different suppression strategies be initiated in similar situations, and for how long it should remain in place.

The study had some limitations, the use of visual extrapolation from one case to another is not statistically sophisticated, however our results for France were close to the middle range predictions in Massonnaud et al. study [5]. We were not able to determine if the change in the reproduction rate (R_0) for the infection as a result for the suppression strategies would be as responsive in France, Italy, and Spain as it was in China, but there is no previous evidence to contradict that. Also, the use of a constant R_0 throughout the study forecasting duration would be against the assumption that the suppression strategies would invert the R_0 , therefore we do not believe a constant R_0 should be used in such case. Moreover, the uncertainty around the disease itself and how it could impact different populations is another limitation that we have faced, but nothing is currently known about that, and it is an area for future research. Lastly, we do not know if people in the European nations would behave similar to the Chinese when the suppression strategies are implemented and kept in place for some time, and since there is no evidence against that we assumed that they would behave the same way.

Conclusion

The current epidemic is a very challenging time for all countries in the world, and it is time for solidarity for all nations in the world, otherwise everyone loses. Italy, followed by Spain, will be the most impacted countries in the European Union (EU). Moreover, the healthcare systems in Italy and Spain will need the support from the EU and other international organizations, such as the United Nations and WHO, to be sustained, otherwise the system will collapse and people in Italy and Spain will lose hope, they will panic for their lives, and nobody knows what will happen after that. Therefore, the support for Italy and Spain with everything, especially medically trained personnel, at this time is very needed and some countries in the world have already started sending their support.

Declarations

Ethics approval and consent to participate: Not applicable

Consent for publication: Not applicable

Availability of data and materials: All data used during this study are publicly available from the WHO.

Competing interests: The authors declare that they have no competing interests

Funding: Not applicable

Authors' contributions: Omar A. Almohammed designed the study, reviewed and analyzed the data, and participated in writing the manuscript. Abdullah A Alhifany and Yazed S. Al-Ruthia reviewed the analysis and were major contributor in writing the manuscript. All authors read and approved the final manuscript.

Acknowledgment: Not applicable

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Figures

Figure 1

The number of new confirmed cases of COVID-19 in China, the mitigation strategies implemented, and the time from implantation till response

Figure 2

The number of new confirmed cases of COVID-19 in France, the mitigation strategies implemented, and the extrapolated cases

Figure 3

The number of new confirmed cases of COVID-19 in Italy, the mitigation strategies implemented, and the extrapolated cases

Figure 4

The number of new confirmed cases of COVID-19 in Spain, the mitigation strategies implemented, and the extrapolated cases