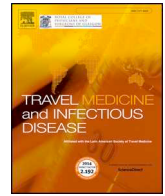




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# Travel Medicine and Infectious Disease

journal homepage: [www.elsevier.com/locate/tmaid](http://www.elsevier.com/locate/tmaid)

## The reproductive number $R_0$ of COVID-19 in Peru: An opportunity for effective changes

### ARTICLE INFO

#### Keywords:

Basic reproduction number  
 COVID-19  
 Coronavirus  
 Peru (Source: MeSH NLM)

#### Dear Editor

On December 31, 2019, the city of Wuhan, from the People's Republic of China, reported to the World Health Organization (WHO) around twenty-seven cases of pneumonia of unknown etiology, which was identified on January 7, 2020, as new coronavirus (nCoV) [1]. Subsequently, the WHO named it as COVID-19 (Coronavirus Disease 2019).

Peru reported, on March 06, the first imported case of COVID-19 in a Peruvian man with travel history to Europe. Then, other cases were confirmed among his relatives [2]. Given the increase in the number of cases, on March 15, the Peruvian president declared a State of Emergency, compulsory social isolation, and international border closure.

The mechanism of transmission of COVID-19 is through person-to-person contact. For this reason, it is important to evaluate the likelihood of the spread of the disease in Peru and the Lima province. Therefore, we aimed to estimate the reproductive number ( $R_0$ ) of COVID-19 during its early outbreak in the Lima province and Peru.

$R_0$  was calculated to estimate the spread of COVID-19 in the Lima province and Peru. The  $R_0$  is a measure to quantify the probability of new cases that result from an effective contact with an infected individual. It depends on a specific point in time and the social behavior of a community. Therefore, it is unique for a specific population and region.

Data was extracted the reports of the Peruvian Ministry of Health. The "incidence" package was used to calculate the incidence in the selected 5-day time frame. Moreover, we retrieved the  $R_0$  with the Poisson likelihood technique using the "earlyR" package and made the graphics with the "ggplot2" package. All analysis was made in the R software version 3.6.2.

The overall basic reproductive number of Peru during the outbreak period was 2.97 (See Fig. 1), meaning that a single case could have infected almost 3 different persons. Lima had a similar outcome with an  $R_0$  of 2.88.

After the declaration of the State of Emergency, the  $R_0$  are expected to decrease. However, several remarks may point towards a sustained or increased  $R_0$  in the population. First, the number of cases could increase due to a delay in the delivery of swab samples to Lima and the subsequent test results to the respective provinces. During this early phase of the outbreak, the only available laboratory was the National

Institute of Health (INS), located in Lima. Therefore patients in other provinces had to wait more than 3 days for their laboratory result [3], which may have resulted in a higher transmission rate and an improper medical management and isolation containment of the true cases. Second, the place where the sample was taken could increase the rate of false negatives. A recent report [4] indicated that the results of molecular tests, such as RT-PCR, depend on where it is obtained. This is because there is a difference between bronchoalveolar lavage fluid specimens (93%) compared to the nasal swabs (63%) and pharyngeal swabs (32%); the last one is the location where health personnel take the samples of the Peruvian suspected cases.

Other causes for the high  $R_0$  could be that, despite the State of Emergency, the population have not respected the quarantine. A local report identified persistent mass gatherings in different parts of the country [5], and an estimated of 16,000 detainees for inflicting the temporary Government restrictions. Furthermore, several individuals did not respect the require "social distancing" between person to person. Studies highlight that "social distancing" is one of the pivotal public health measures to reduce the transmission in places where there is evidence of community transmission [6].

These results identified the likelihood of the spread of COVID-19 in Lima province and Peru. Moreover, the behaviors of several individuals against the Government mitigation actions suggest that the spread will, in fact, increase. Moreover, is expected that Peru reduces the time of cases identification by decentralizing testing laboratories and the implementation of antigen-antibody tests.

#### Authors' contributions

JST, ICK conceived the research idea and collected the data. JST, ICK, BV perform the first version of the manuscript. JST, ICK, BV authors designed the study. ICK, BV performed the statistical. CDV and CL provided the critical review of the manuscript. All authors drafted the manuscript and approved the final version.

#### Declaration of competing interest

The author declare that no competing interests exist.

<https://doi.org/10.1016/j.tmaid.2020.101689>

Received 28 March 2020; Received in revised form 17 April 2020; Accepted 18 April 2020  
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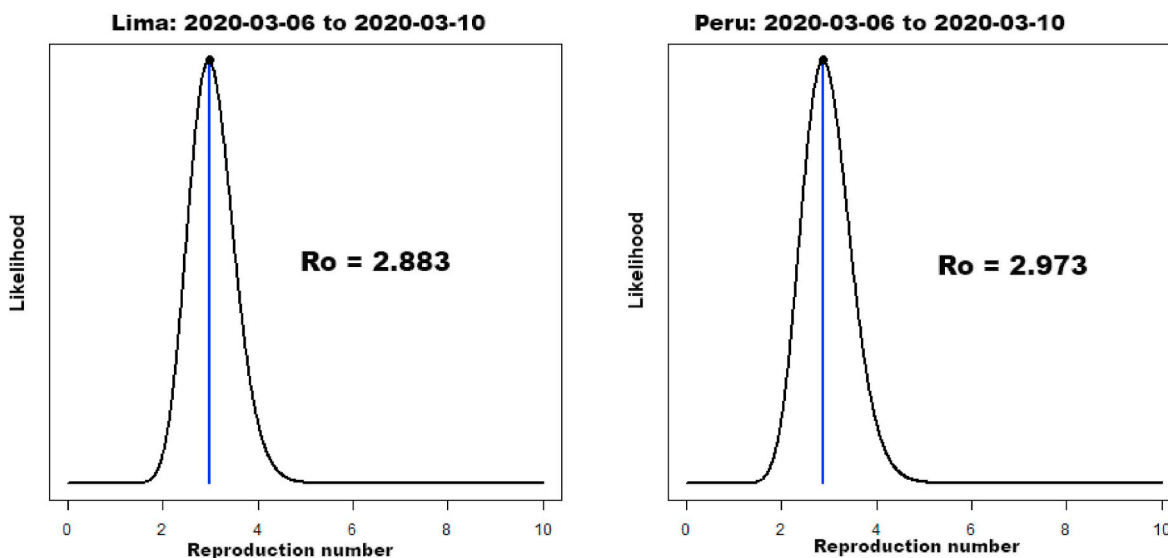


Fig. 1. The distribution of the reproductive number ( $R_0$ ) with the Maximum-Likelihood (ML) estimation for COVID-19 in Lima province and Peru.

## Acknowledgements

Thanks to Dr. Sanz-Anquela JM., for the given advice in this work and Lopez-Abente G., for the provide us the routine in R with which carry out the calculations for the different Autonomous Communities of Spain.

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