Simplified assessment of the evolution of the COVID-19 epidemic in the state of Ceará - Brazil

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Abstract

The COVID-19 pandemic imposed a major challenge on all health systems on the planet. At the regional level, the state of Ceará (Brazil) differs from other Brazilian regions by an early and rapid onset of its cases, probably due to its high international connectivity by air. Health authorities instituted social isolation measures 3 weeks ago. The authors made a graphical inspection of official data on confirmed cases of COVID-19 in Ceará, São Paulo, Brazil and the USA to search for evidence that can help assess the strategy of local health authorities. Logarithmic scale graphs of new cases per day and cumulative cases indicate a high risk situation for the epidemic in Ceará. The tendency for the pandemic to grow seems to be greater in Ceará than in the state of São Paulo, in the whole of Brazil and even in the USA, the country with the greatest growth of the epidemic recently. The maintenance and even the tightening up of social isolation measures seem a logical conclusion to this panorama.

Introduction

On December 31, 2019, 27 cases of viral pneumonia were reported in the city of Wuhan, China. A new coronavirus, related to SARS-Cov and MERS-Cov, was isolated from the patients' airways, being initially named 2019-nCov (Zhu et al., 2020). The sequence of events that followed gave rise to the current pandemic of the new coronavirus, officially called SARS-Cov-2 (Bedford et al., 2020). Mathematical models of spreading SARS-Cov-2 indicate that screening and isolating cases and contacts is not sufficient to contain the epidemic if there is a significant number of asymptomatic patients transmitting the virus (Hellewell et al., 2020). Quarantine and social isolation measures can be effective for their control, based on what happened in China (Anastassopoulou et al., 2020; Hou et al., 2020). In the state of Ceará, the first case was officially registered on March 15, 2020, five days after community transmission of the virus was declared and, as of today (April 5), 823 confirmed cases have accumulated. Quickly identifying the parameters of the COVID-19 epidemic is important in deciding what appropriate measures to take. The authors have used a simplified approach to graphical inspection of official data to date to define what stage of the epidemic we are in our state and whether the measures adopted have already changed the growth of cases.

Methods

Data source:

The data were obtained from official sources. The number of confirmed cases per day and the cumulative total in Ceará was obtained from the Ceará State Government information site, IntegraSUS (do Estado do

Ceará, 2020). The number of confirmed cases per day and the cumulative total in the state of São Paulo was obtained from the coronavirus information site in the state of São Paulo (do Estado de São Paulo, 2020). The number of confirmed cases per day and the cumulative total in Brazil and the USA was obtained from the Worldometer (Worldometers.info, 2020) website.

Statistical analysis:

The data were used to build a graph of evolution of the daily and cumulative number of cases over time, between 03/15/2020 and 04/04/2020 (fig. 1). To provide support for a semi-quantitative assessment through visual inspection of the graphs and comparison of metrics, we constructed graphs plotting the number of new cases versus the total cumulative number each day, both on a logarithmic scale (Fig. 2).

Using the least squares method, we performed a linear regression with the data obtained, calculating the coefficient of determination (R^2) as a surrogate metric to assess the departure of the data from an ideal linear model. The program used was Google Sheets (Google, 2020).

Results

The visual inspection of the graph of the number of confirmed cases over time in two Brazilian states, in Brazil as a whole and in the United States of America are similar, approaching a linear trend on a logarithmic scale, which corresponds to a growth exponential on a linear scale (figure 1). This suggests that all territories whose data have been assessed are in the exponential phase of the COVID-19 epidemic, as would be expected.

Visual inspection of the graphs of new cases versus cumulative cases on a logarithmic scale is sensitive to small deviations from the linear model, which indicate trends in the growth of the epidemic. Linear regression and values of R^2 also inform growth trends in the evaluated populations.

The graphs of new cases versus cumulative cases visually show a most pronounced departure from the linear trend in the case of the state of Ceará, indicating a more explosive exponential trend. This deviation appears to be even greater than in the case of the USA, which constitute the territory with the highest number of cases and the fastest growing epidemic on the planet (figure 2). The values of the coefficient of determination are greater than 0.8 in the case of Brazil and the USA, indicating a good correlation between the data and the model. In the case of Ceará and São Paulo, the R^2 is less than 0.7, being closer to 0.6 in the case of our state. This indicates a smaller correlation between the data and the model.

Suplement

This version is a translation from the original version in portuguese. Link: https://bit.ly/2XIL4vE

Data and graphs can be visualized on google sheets: https://bit.ly/2VtKsaA

Discussion

This simplified assessment may suggest that the growing trend of the COVID-19 epidemic has not yet been inhibited in Ceará, and that there is less reliability in forecasts from the data in the case of our state. One hypothesis that can be raised is that the epidemic is not controlled in Ceará. Another hypothesis is that local data are incomplete or skewed in some way (for example, by the recent change in the testing indication for the virus).

The state of Ceará is one of the most affected in the Brazilian territory by the COVID-19 pandemic. This is in contrast to other neighboring states and the hypothesis that virus transmission is reduced near the equator (Sajadi et al., 2020). An analysis of air traffic data estimated that air connectivity correlates positively with

the spread of COVID-19 (Salazar et al., 2020). Fortaleza, capital of Ceará, has considerably increased its air connectivity in recent years by installing an air hub for Europe and expanding its air transport operations (de Castro, 2018). This may be one of the most important determining factors for the precocity of the COVID-19 epidemic in our state. Three weeks ago, health authorities instituted measures to contain the epidemic (quarantine, social isolation) in our state. There is still no evaluation on the response to these measures.

Previous experience with the SARS pandemic (Wallinga, 2004) has shown that the epidemic curve can be fundamentally different in different affected regions even when connected geographically and temporally. It also showed that the preparation and institution of adequate measures to prevent and combat the epidemic are essential. Mathematical models have shown that the current new pandemic of COVID-19 has the potential to cause large numbers of deaths and collapse of health systems (Wu et al., 2020). A mathematical model recently developed by Brazilian researchers showed a high risk of collapse of health resources in the country and predicted that the measures currently underway (quarantine, social isolation) need to be maintained for a longer time, or else the effort may not have favorable result (Bastos and Cajueiro, 2020).

Our results from a simplified semi-quantitative assessment also indicate that efforts to contain the pandemic in the state of Ceará need to continue, as we are probably on the verge of entering the more accelerated phase of the exponential curve of the epidemic. In addition, there should be an increased effort to test and provide transparent information on the evolution of the epidemic.

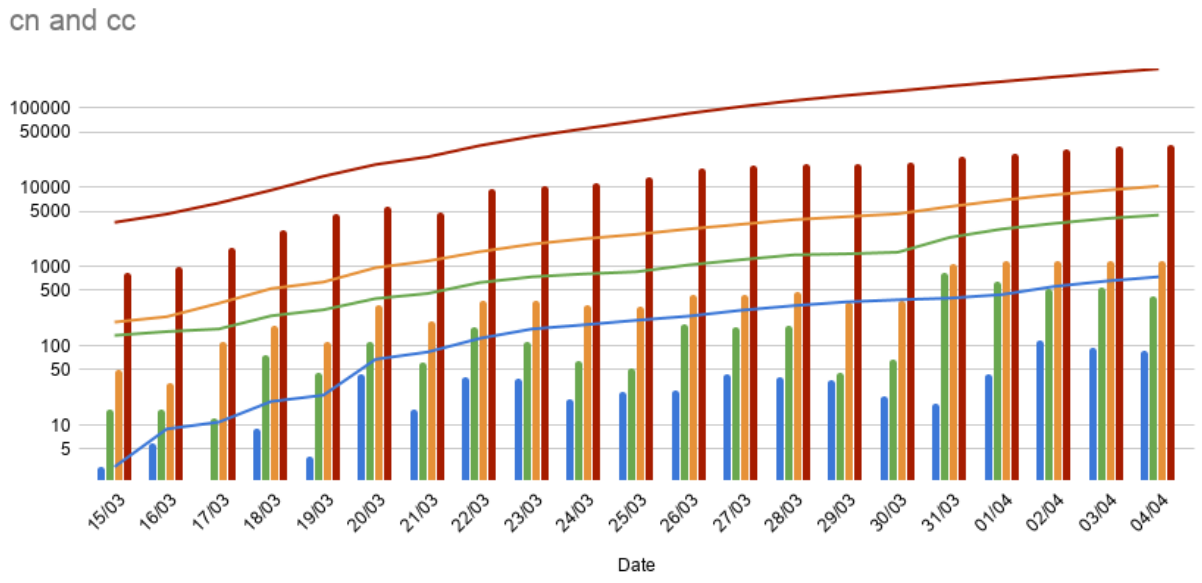

Figure 1: Daily new cases (cn - columns) and cumulative confirmed cases (cc - lines) of COVID-19 in Ceará (blue), São Paulo (green), Brazil (orange) and USA (red). Logarithmic scale.

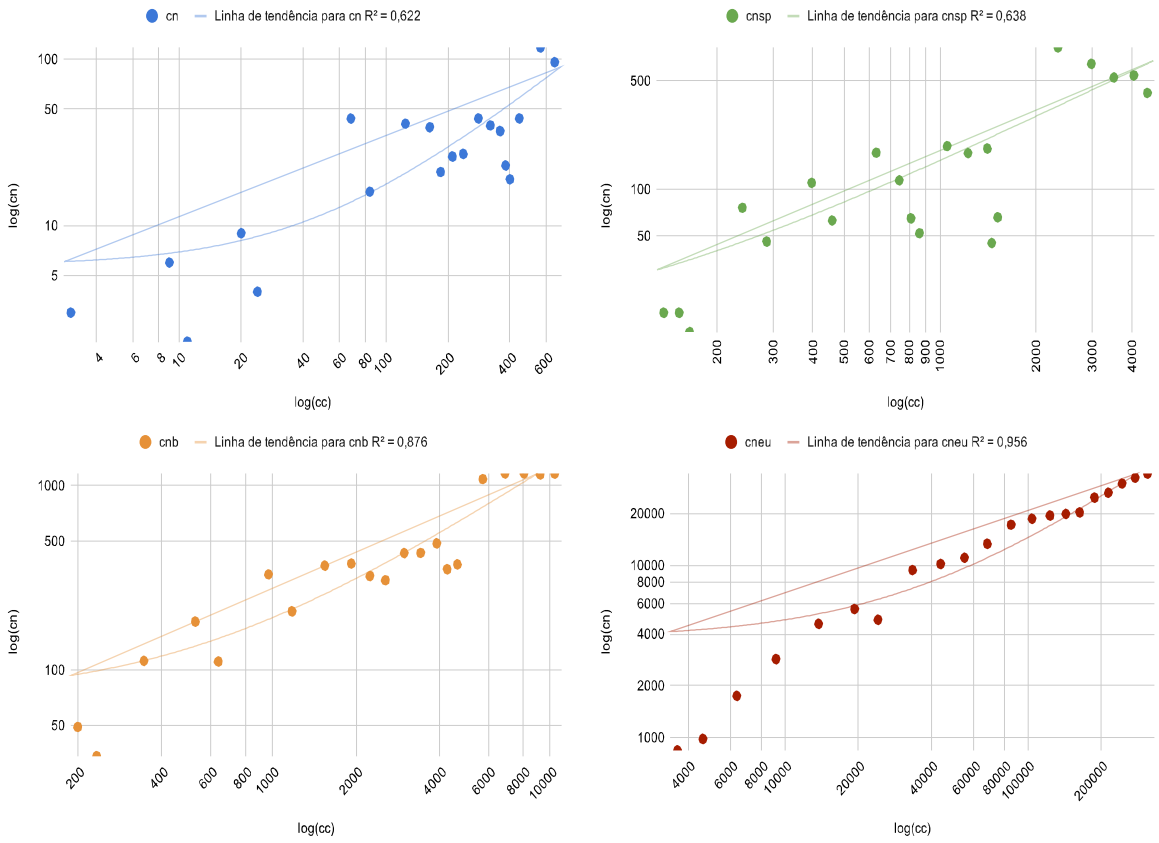

Figure 2: Log scale graph of daily new cases (cn) versus cumulative cases (cc) and linear regression trend using the least squares method. Cases on Ceará (blue), São Paulo (green), Brazil (orange) and USA(red).

References

C Anastassopoulou, L Russo, A Tsakris, and C Siettos. Data-based analysis, modelling and forecasting of the COVID-19 outbreak. *PLoS One*, 15:e0230405, 2020.

Saulo B Bastos and Daniel O Cajueiro. Modeling and forecasting the Covid-19 pandemic in Brazil. arXiv:2003.14288 [q-bio.PE]. https://arxiv.org/abs/2003.14288, 2020. URL https://arxiv.org/abs/2003.14288v1. Accessed on Thu, April 09, 2020.

J Bedford, D Enria, J Giesecke, DL Heymann, C Ihekweazu, G Kobinger, HC Lane, Z Memish, MD Oh, AA Sall, A Schuchat, K Ungchusak, and LH Wieler. COVID-19: towards controlling of a pandemic. *Lancet*, 395:1015–1018, Mar 2020.

Livia Maria Oliveira de Castro. Conectividade aérea e comércio exterior: os efeitos do hub aéreo nas exportações e as repercussões na economia cearense. Master's thesis, Faculdade de Economia, Administração, Atuária e Contabilidade - FEAAC, Programa de Economia Profissional - PEP, Universidade Federal do Ceará - UFC, 2018. URL http://www.repositorio.ufc.br/handle/riufc/37351.

Governo do Estado de São Paulo. Coronavírus. Casos em São Paulo. Disponível em:

¡https://www.seade.gov.br/coronavirus/¿ Acesso em: 05 abr. 2020, 2020. URL https://www.seade.gov.br/coronavirus/.

Governo do Estado do Ceará. Boletim epidemiológico novo coronavírus (COVID-19). Disponível em: ¡https://indicadores.integrasus.saude.ce.gov.br/indicadores/indicadores-coronavirus/coronavirus-ceara¿ Acesso em: 05 abr. 2020, 2020. URL https://indicadores.integrasus.saude.ce.gov.br/indicadores/indicadores-coronavirus/coronavirus-ceara.

J Hellewell, S Abbott, A Gimma, NI Bosse, CI Jarvis, TW Russell, JD Munday, AJ Kucharski, WJ Edmunds, S Funk, and RM Eggo. Feasibility of controlling COVID-19 outbreaks by isolation of cases and contacts. *Lancet Glob Health*, 8:e488–e496, Apr 2020.

Can Hou, Jiaxin Chen, Yaqing Zhou, Lei Hua, Jinxia Yuan, Shu He, Yi Guo, Sheng Zhang, Qiaowei Jia, Chenhui Zhao, Jing Zhang, Guangxu Xu, and Enzhi Jia. The effectiveness of the quarantine of Wuhan city against the Corona Virus Disease 2019 (COVID-19): well-mixed SEIR model analysis. *Journal of Medical Virology*, apr 2020. doi: 10.1002/jmv.25827. URL https://doi.org/10.1002%2Fjmv.25827.

Mohammad M. Sajadi, Parham Habibzadeh, Augustin Vintzileos, Shervin Shokouhi, Fernando Miralles-Wilhelm, and Anthony Amoroso. Temperature and Latitude Analysis to Predict Potential Spread and Seasonality for COVID-19. *SSRN Electronic Journal*, 2020. doi: 10.2139/ssrn.3550308. URL https://doi.org/10.2139%2Fssrn.3550308.

Pablo Martinez De Salazar, René Niehus, Aimee Taylor, Caroline O'Flaherty Buckee, and Marc Lipsitch. Identifying Locations with Possible Undetected Imported Severe Acute Respiratory Syndrome Coronavirus 2 Cases by Using Importation Predictions. *Emerging Infectious Diseases*, 26(7), jul 2020. doi: 10.3201/eid2607.200250. URL https://doi.org/10.3201%2Feid2607.200250.

J. Wallinga. Different Epidemic Curves for Severe Acute Respiratory Syndrome Reveal Similar Impacts of Control Measures. *American Journal of Epidemiology*, 160(6):509–516, sep 2004. doi: 10.1093/aje/kwh255. URL https://doi.org/10.1093%2Faje%2Fkwh255.

Worldometers.info. COVID-19 Coronavirus pandemic. Disponível em: ¡https://www.worldometers.info/coronavirus/¿ Acesso: 05 abr. 2020, 2020. URL https://www.worldometers.info/coronavirus/.

Joseph T Wu, Kathy Leung, and Gabriel M Leung. Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan China: a modelling study. *The Lancet*, 395(10225):689–697, feb 2020. doi: 10.1016/s0140-6736(20)30260-9. URL https://doi.org/10.1016%2Fs0140-6736%2820%2930260-9.

N Zhu, D Zhang, W Wang, X Li, B Yang, J Song, X Zhao, B Huang, W Shi, R Lu, P Niu, F Zhan, X Ma, D Wang, W Xu, G Wu, GF Gao, and W Tan. A Novel Coronavirus from Patients with Pneumonia in China, 2019. *N Engl J Med*, 382:727–733, Feb 2020.