



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



ELSEVIER

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

Research letter

COVID-19 epidemic in Brazil: Where are we at?

Andréa de Paula Lobo^{a,*}, Augusto César Cardoso-dos-Santos^b, Marli Souza Rocha^b,
Rejane Sobrino Pinheiro^c, João Matheus Bremm^b, Eduardo Marques Macário^b,
Wanderson Kleber de Oliveira^b, Giovanny Vinícius Araújo de França^b

^a Collective Health Program, Faculty of Health Science, University of Brasília, Brasília-DF, Brazil

^b Secretariat of Health Surveillance, Ministry of Health, Brasília-DF, Brazil

^c Institute of Public Health Studies, Health Science Center, Federal University of Rio de Janeiro, Rio de Janeiro-RJ, Brazil



ARTICLE INFO

Article history:

Received 22 May 2020

Received in revised form 10 June 2020

Accepted 12 June 2020

Keywords:

COVID-19

Times series

Epidemiology

Brazil

Joinpoint

ABSTRACT

Objective: To analyze the trends of COVID-19 in Brazil in 2020 by Federal Units (FU).

Method: Ecological time-series based on cumulative confirmed cases of COVID-19 from March 11 to May 12. Joinpoint regression models were applied to identify points of inflection in COVID-19 trends, considering the days since the 50th confirmed case as time unit.

Results: Brazil reached its 50th confirmed case of COVID-19 in 11 March 2020 and, 63 days after that, on May 12, 177,589 cases had been confirmed. The trends for all regions and FU are upward. In the last segment, from the 31st to the 63rd day, Brazil presented a daily percentage change (DPC) of 7.3% (95%CI= 7.2;7.5). For the country the average daily percentage change (ADPC) was 14.2% (95%CI: 13.8;14.5). The highest ADPC values were found in the North, Northeast and Southeast regions.

Conclusions: In summary, our results show that all FUs in Brazil present upward trends of COVID-19. In some FUs, the slowdown in DPC in the last segment must be considered with caution. Each FU is at a different stage of the pandemic and, therefore, non-pharmacological measures should be adopted accordingly.

© 2020 The Authors. Published by Elsevier Ltd on behalf of International Society for Infectious Diseases.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction: Brazil was the first South American country to report a confirmed case of Coronavirus Disease 2019 (COVID-19), on February 26, 2020, in São Paulo state [1]. Since then, the country has presented a complex epidemiological scenario, with marked regional differences. Here, we aimed to analyze the trends of COVID-19 in Brazil in 2020 by Federal Units (FU).

Methods: We carried out an ecological time-series study based on cumulative confirmed cases of COVID-19 from March 11 to May 12. We used official data available at the Brazilian Ministry of Health webpage (<https://covid.saude.gov.br/>). Joinpoint regression models were applied to identify points of inflection in COVID-19 trends, considering the days since the 50th confirmed case as time unit. The magnitude of change in the number of cumulative cases in each segment (period between two inflections) was estimated through the daily percentage change (DPC), with a 95% confidence interval (95%CI). The number of segments was chosen according to

the best fit indicated by the algorithm. The average daily percentage change (ADPC) represents the percentage change for the whole period. The analyses were performed using the National Cancer Institute's Joinpoint software [2], assuming a 5% significance level.

Results: On March 11, Brazil reached the 50th confirmed case of COVID-19 and, 63 days after that, on May 12, 177,589 cases had been confirmed (26,9% in São Paulo state). We observed upward trends for all regions and FUs (Table 1). In the last segment, from the 31st to the 63rd day, Brazil presented a DPC of 7.3% (95%CI = 7.2;7.5) (Table 2).

At region level, the highest ADPC values were found in the North, Northeast and Southeast regions. São Paulo presented the greatest increase at the beginning of the epidemic (segment 1: DPC = 51.8%; 95%CI = 30.7;76.2). In the last segment, São Paulo had a DPC of 6.1% (95%CI = 5.8;6.3), with a 6-fold increase in 32 days. As São Paulo, Amazonas, Pernambuco, Ceará, and Rio de Janeiro at a more advanced stage of the epidemic (around 45–50 days after the 50th case), compared other states, such as Rondônia, Sergipe and Tocantins. Some FUs, such as Pará, Pernambuco, São Paulo, Paraná,

* Corresponding author. Collective Health Program, Faculty of Health Science, University of Brasília, Brasília-DF, Brazil, 70910-900. Tel.: +55 61 981288920.
E-mail address: andreadpaula@gmail.com (A.d.P. Lobo).

Table 1
Joinpoint analysis for accumulated cases of COVID-19 in Brazil by day, 2020

Federative Units	Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Segment 6		ADPC % (95% CI)
	AR-D	DPC % (95% CI)	AR-D	DPC % (95% CI)	AR-D	DPC % (95% CI)	AR-D	DPC % (95% CI)	AR-D	DPC % (95% CI)	AR-D	DPC % (95% CI)	
Brazil	1-12	36.4*(35.3;37.5)	12-24	15.6*(14.6;16.5)	24-31	12.0*(9.7;14.3)	31-63	7.3*(7.2;7.5)					14.2*(13.8;14.5)
North	1-3	31.7*(23.5;40.4)	3-7	20.9*(17.1;24.9)	7-12	14.3*(12.0;16.6)	12-18	21.8*(20.1;23.6)	18-48	10.1*(10.0;10.2)	48-51	5.8*(2.5;9.3)	13.3*(12.7;13.8)
Amazonas	1-5	26.7*(22.8;30.7)	5-10	13.6*(10.1;17.1)	10-15	25.8*(22.0;29.8)	15-23	9.9*(8.4;11.3)	23-26	5.2 (-4.6;16)	26-49	9.1*(8.9;9.3)	12.5*(11.6;13.4)
Roraima	1-11	15.4*(14.1;16.7)	11-20	7.9*(6.3;9.6)	20-30	10.3*(8.8;11.7)	30-34	3.9 (-0.6;8.6)					10.3*(9.4;11.2)
Amapá	1-7	19.0*(17.1;21.0)	7-15	5.6*(4.2;7.0)	15-19	13.1*(7.7;18.7)	19-25	7.6*(5.2;9.9)	25-28	17.0*(6.2;29.0)	28-35	5.6*(4.3;7.0)	10.1*(8.8;11.3)
Pará	1-5	27.2*(21.4;33.3)	5-8	7.6 (-7.2;24.8)	8-21	17.1*(16.1;18.1)	21-40	10.4*(9.9;10.9)					14.0*(12.6;15.4)
Tocantins	1-9	22.2*(20.2;24.4)	9-18	15.4*(13.7;17.1)									18.6*(17.4;19.8)
Rondônia	1-3	8.5*(1.4;16.1)	3-8	21.0*(18.5;23.7)	8-13	13.5*(11.1;16.0)	13-16	6.9(-0.1;14.4)	16-25	11.6*(10.8;12.4)	25-29	4.7*(2.5;7.0)	11.8*(10.7;12.9)
Acre	1-10	9.0*(8.1;10.0)	10-16	11.5*(9.1;13.9)	16-23	6.4*(4.6;8.1)	23-28	16.2*(12.7;19.8)	28-34	12.7*(10.3;15.2)	34-37	6.0*(0.9;11.3)	10.2*(9.3;11.1)
Northeast	1-5	34.2*(31.2;37.3)	5-22	14.8*(14.5;15.1)	22-38	10.8*(10.5;11.2)	38-55	8.0*(7.7;8.2)					12.7*(12.5;13.0)
Maranhão	1-5	15.3*(11.2;19.5)	5-8	32.2*(17.9;48.3)	8-14	13.5*(10.6;16.4)	14-19	19.7*(15.4;24.1)	19-42	8.9*(8.6;9.1)			13.0*(11.8;14.2)
Piauí	1-6	20.4*(18.4;22.5)	6-21	12.5*(12.1;12.9)	21-27	8.8*(7.0;10.6)	27-30	5.1*(1.2;9.1)					12.2*(11.6;12.9)
Ceará	1-4	44.8*(34.0;56.5)	4-20	13.6*(12.9;14.4)	20-37	9.1*(8.4;9.7)	37-54	7.8*(7.2;8.4)					11.8*(11.2;12.4)
Rio Grande do Norte	1-4	8.0*(1.2;15.3)	4-7	37.1*(20.4;56.0)	7-13	3.3*(0.4-6.4)	13-36	7.4*(7.0;7.7)	36-45	4.6*(3.4;5.8)			8.1*(6.9;9.2)
Pernambuco	1-7	10.1*(7.9;12.4)	7-16	25.8*(24.2;27.5)	16-22	15.8*(12.7;19.0)	22-35	10.1*(9.3;10.9)	35-47	6.3*(5.6;7.1)			12.7*(12.1;13.4)
Paraíba	1-6	18.1*(14.8;21.4)	6-14	10.3*(8.5;12.2)	14-24	13.0*(11.7;14.3)	24-34	10.7*(9.6;11.8)					12.4*(11.6;13.2)
Sergipe	1-11	12.7*(11.1;14.3)	11-14	31.7*(9.9;57.8)	14-23	15.1*(12.8;17.4)	23-26	7.9(-1.5;18.1)					15.1*(12.4;17.9)
Alagoas	1-19	19.2*(18.6;19.8)	19-30	6.4*(5.3;7.4)									14.2*(13.6;14.7)
Bahia	1-9	15.9*(14.9;16.8)	9-15	13.1*(11.2;15.0)	15-23	7.5*(6.5;8.6)	23-32	9.9*(9.0;10.8)	32-51	6.7*(6.5;7.0)			9.6*(9.3;10.0)
Southeast	1-12	31.0*(29.6;32.4)	12-19	12.6*(9.7;15.7)	19-22	23.4*(5.5;44.4)	22-31	10.8*(8.9;12.7)	31-62	6.2*(6.0;6.4)			12.6*(11.6;13.5)
São Paulo	1-3	51.8*(30.7;76.2)	3-11	25.8*(23.3;28.4)	11-18	12.3*(9.5;15.2)	18-21	28.9*(11.0;49.7)	21-29	10.7*(8.5;12.9)	29-61	6.1*(5.8;6.3)	12.3*(11.2;13.4)
Rio de Janeiro	1-6	36.5*(33.2;39.8)	6-25	12.5*(12.1;12.8)	25-55	6.4*(6.2;6.5)							11.0*(10.7;11.3)
Espírito Santo	1-7	17.3*(15.7;18.9)	7-18	12.1*(11.4;12.8)	18-22	20.7*(16.0;25.6)	22-32	6.4*(5.6;7.2)	32-35	13.1*(4.5;22.5)	35-46	5.9*(5.4;6.5)	10.7*(10.0;11.5)
Minas Gerais	1-16	12.3*(11.7;13.0)	16-52	5.2*(5.0;5.3)									7.2*(7.0;7.4)
South	1-3	47.9*(37.7;58.8)	3-9	20.8*(18.9;22.8)	9-23	11.0*(10.6;11.4)	23-40	3.8*(3.5;4.1)	40-43	9.5*(2.0;17.6)	43-55	4.7*(4.3;5.2)	9.4*(8.8;9.9)
Paraná	1-6	20.1*(18.2;22.1)	6-10	10.3*(6.4;14.3)	10-14	22.1*(17.8;26.5)	14-22	8.4*(7.3;9.4)	22-42	3.5*(3.3;3.7)	42-52	2.6*(2.0;3.2)	7.5*(7.0;8.0)
Rio Grande do Sul	1-7	21.6*(19.6;23.7)	7-19	9.7*(9.0;10.5)	19-34	3.6*(3.1;4.1)	34-53	5.8*(5.5;6.1)					7.8*(7.4;8.1)
Santa Catarina	1-7	20.8*(18.1;23.5)	7-19	9.3*(8.3;10.2)	19-22	18.1*(3.3;35.0)	22-38	3.6*(3.0;4.2)	38-41	17.3*(2.6;34.1)	41-53	5.1*(4.2;5.9)	8.7*(7.4;9.9)
Midwest	1-3	47.5*(36.9;58.8)	3-11	13.8*(12.7;14.9)	11-20	8.1*(7.2;9.0)	20-55	5.4*(5.3;5.5)					8.4*(8.0;8.7)
Mato Grosso	1-7	12.9*(10.8;15.1)	7-33	4.8*(4.6;5.0)	33-39	7.2*(5.2;9.2)							6.4*(6.0;6.9)
Mato Grosso do Sul	1-10	7.3*(6.4;8.3)	10-26	5.8*(5.3;6.2)	26-36	2.3*(1.3;3.2)	36-42	5.8*(4.0;7.6)					5.2*(4.8;5.7)
Goias	1-5	5.7*(2.4;9.0)	5-13	12.5*(11.0;14.0)	13-22	8.8*(7.6;10.0)	22-28	4.0*(1.7;6.3)	28-34	8.6*(6.2;11.1)	34-46	3.4*(2.8;4.0)	7.0*(6.4;7.6)
Distrito Federal	1-9	14.8*(13.9;15.7)	9-16	7.6*(6.2;8.9)	16-39	4.2*(4.0;4.4)	39-54	6.8*(6.5;7.2)					6.9*(6.7;7.2)

AR-D: applicable range (day); DPC: daily percent change and AAPC: average daily percent change. *p < 0.05.

Table 2
Accumulated cases of COVID-19 for each Joinpoint's segment. Brazil and Federated Unit, 2020

Federative Units	Segment 1		Segment 2		Segment 3		Segment 4		Segment 5		Segment 6	
	AR-D	n	AR-D	n	AR-D	n	AR-D	n	AR-D	n	AR-D	n
Brazil	1-12	1.546	12-24	9.056	24-31	19.638	31-63	177.589	...	...	...	...
North	1-3	105	3-7	227	7-12	427	12-18	1.360	18-48	25.565	48-51	30.900
Amazonas	1-5	140	5-10	260	10-15	804	15-23	1.719	23-26	2.044	26-49	14.168
Roraima	1-11	222	11-20	425	20-30	1.124	30-34	1.328	...	...	...	...
Amapá	1-7	307	7-15	479	15-19	798	19-25	1.187	25-28	1.931	28-35	2.910
Pará	1-5	138	5-8	170	8-21	1.267	21-40	8.616	...	...	...	...
Tocantins	1-9	246	9-18	828	...	...	...	...	...	...	...	...
Rondônia	1-3	76	3-8	199	8-13	364	13-16	433	16-25	1.222	25-29	1.460
Acre	1-10	101	10-16	195	16-23	311	23-28	657	28-34	1.335	34-37	1.590
Northeast	1-5	308	5-22	3.242	22-38	16.293	38-55	58.316	...	...	...	...
Maranhão	1-5	96	5-8	230	8-14	478	14-19	1.205	19-42	8.526	...	...
Piauí	1-6	123	6-21	742	21-27	1.233	27-30	1.443	...	...	...	...
Ceará	1-4	163	4-20	1.291	20-37	5.421	37-54	18.412	...	...	...	...
Rio Grande do Norte	1-4	92	4-7	212	7-13	263	13-36	1.392	36-45	2.033	...	...
Pernambuco	1-7	106	7-16	816	16-22	2.006	22-35	6.876	35-47	14.309	...	...
Paraíba	1-6	136	6-14	301	14-24	1.034	24-34	2.777	...	...	...	...
Sergipe	1-11	197	11-14	447	14-23	1.588	23-26	2.032	...	...	...	...
Alagoas	1-19	1.226	19-30	2.580	...	...	...	...	...	...	...	...
Bahia	1-9	213	9-15	431	15-23	759	23-32	1.789	32-51	6.204	...	...
Southeast	1-12	1.135	12-19	2.507	19-22	4.988	22-31	12.125	31-62	74.727	...	...
São Paulo	1-3	136	3-11	745	11-18	1.517	18-21	3.506	21-29	8.216	29-61	47.719
Rio de Janeiro	1-6	305	6-25	2.855	25-55	18.486	...	...	...	...	...	...
Espírito Santo	1-7	139	7-18	463	18-22	952	22-32	1.874	32-35	2.662	35-46	5.087
Minas Gerais	1-16	525	16-52	3.435	...	...	...	...	...	...	...	...
South	1-3	154	3-9	463	9-23	1.972	23-40	3.741	40-43	4.958	43-55	8.556
Paraná	1-6	119	6-10	179	10-14	395	14-22	738	22-42	1.492	42-52	1.906
Rio Grande do Sul	1-7	195	7-19	555	19-34	994	34-53	2.917	...	...	...	...
Santa Catarina	1-7	149	7-19	457	19-22	732	22-38	1.337	38-41	2.085	41-53	3.733
Midwest	1-3	138	3-11	399	11-20	783	20-55	5.090	...	...	...	...
Mato Grosso	1-7	112	7-33	379	33-39	591	...	...	...	...	...	...
Mato Grosso do Sul	1-10	97	10-26	234	26-36	288	36-42	405	...	...	...	...
Goiás	1-5	71	5-13	179	13-22	378	22-28	486	28-34	781	34-46	1.115
Distrito Federal	1-9	260	9-16	454	16-39	1.146	39-54	2.979	...	...	...	...

AR-D:applicable range (day).

and Goiás showed a reduction in DPC in last segment in comparison with the previous one (Table 1).

Discussion: Although all FUs presented upward trends in the number of cumulative cases of COVID-19, 18 out of 27 FUs showed a reduction in the pace of the trend in the last segment. This may be related to the non-pharmacological measures adopted [3,4]. Despite the recent slowdown, 25 FUs still present significant upward trends. Some of them, such as Amazonas, Rio Grande do Sul, Mato Grosso, Mato Grosso do Sul and Distrito Federal even showed an increase in the DPC in the last segment. We highlight that the FUs are at different stages of the epidemic, which can also explain those differences.

Even though the FUs from the Southeast region presented most of the confirmed cases, the highest ADPC values were found in the Northeast and North regions. This is particularly troublesome because these regions present the lowest human development indices, and the highest proportion of poverty and low education rates in Brazil [5].

Some factors may have affected the inflections of the curves, such as the availability of diagnostic tests and the sensitivity of the epidemiological and laboratory surveillance system [4,6]. As we used publicly available data, analyses were performed using the notification date rather than the symptoms onset date, as well as the cumulative cases instead of incident cases.

In future analyzes, other information will be added to investigate the inflections in the curve of a given territory, such as the validity of municipal or state decrees (lockdown and other restrictive measures), the proportion of population isolation per day and the number of tests performed.

In summary, our results show that all FUs in Brazil present upward trends of COVID-19. In some FUs, the slowdown in DPC in the last segment must be considered carefully. Each FU is at a different stage of the pandemic and, therefore, non-pharmacological measures must be applied accordingly.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest statement: None

Ethical approval: This work was developed with secondary data and approval by an ethics committee is not necessary.

Author contributions: LOBO A.P had full access to all the data in the study and take responsibility for the integrity of the data and analysis.

Concept and design: All authors.

Interpretation of data: All authors.

Drafting of the manuscript: LOBO A.P; CARDOSO-DOS-SANTOS, A.C; ROCHA M.S

Critical revision of the manuscript for important intellectual content: PINHEIRO, R.S; FRANÇA, G.V.S; BREMM J.M; MACARIO E. M; OLIVEIRA W.K

Statistical analysis: LOBO A.P.

References

- Burki T. COVID-19 in Latin America. *The Lancet*. Issue 5 [1];547–8, doi:http://dx.doi.org/10.1016/S1473-3099(20)30303-0 May 01.
- National Cancer Institute. *Statistical Methodology and Applications Branch. Joinpoint Regression Program Version 4.2.0 - April 2015*. Washington: Surveillance Research Program. National Cancer Institute; 2015.

- Nussbaumer-Streit B, Mayr V, Dobrescu Alulia, Chapman A, Persad E, Klerings I, Wagner G, Siebert U, Christof C, Zachariah C, Gartlehner G. Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. *Cochrane Database of Systematic Reviews* [3];. doi:<http://dx.doi.org/10.1002/14651858.CD013574> Issue 4. Art. No.: CD013574.
- Fang Y, Nie Y, Penny M. Transmission dynamics of the COVID-19 outbreak and effectiveness of government interventions: A data-driven analysis. *J Med Virol*. [4];92:645–59, doi:<http://dx.doi.org/10.1002/jmv.25750>.
- Síntese de indicadores sociais: uma análise das condições de vida da população Brasileira:2018. IBGE. 2018. n. 39. 151 p.
- Lana Raquel Martins, Coelho Flávio Codeço, Gomes Marcelo Ferreira da Costa, Cruz Oswaldo Gonçalves, Bastos Leonardo Soares, Villela Daniel Antunes Maciel et al. Emergência do novo coronavírus (SARS-CoV-2) e o papel de uma vigilância nacional em saúde oportuna e efetiva. *Cad. Saúde Pública* [Internet]. 2020; 36 (3): e00019620. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-311X2020000300301&lng=en.