Misinformation Caused Increased Urban Mobility and the End of Social Confinement Before the Second Wave of COVID-19 in Amazonia

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Abstract

Tendentious projections about COVID-19 in Brazil provided an appealing excuse for individuals and decision-makers to justify poor choices during a critical phase of the pandemic. The erroneous results likely contributed to premature resumption of in-person school classes and easing of restrictions on social contact, favoring the resurgence of COVID-19. In Manaus, the largest city in the Amazon region, the COVID-19 pandemic did not end in 2020 of its own accord, but rather rebounded in a disastrous second wave of the disease.

Keywords Amazon · Brazil · COVID-19 · Prevention · Public health · Social confinement · Virus coevolution

Non-pharmacological measures such as social confinement have played an important role in containing the COVID-19 pandemic throughout the world, especially prior to the availability of vaccines. The early ending of these measures has always carried the risk of a new resurgence of cases [1]. Brazil had one of the world's worst records in handling the COVID-19 pandemic, as clearly shown by the 1079-page report of the parliamentary commission of inquiry of Brazil's Federal Senate, released in October 2022 [2]. At the time of the report, Brazil had 2.7% of the world's population yet accounted for 12.3% of the deaths from COVID-19. Manaus, a city of 2.2 million in Brazil's Amazon region, gained notoriety for being the world's first city to bury is COVID-19 dead in mass graves during the first wave of the pandemic in April and May 2020 and then for the specter of people dying in hospitals for lack of oxygen during the second wave in January 2021 (Fig. 1). Manaus had one of the worst responses to the COVID-19 pandemic, resulting in a catastrophic second wave in January 2021 that collapsed the health and funeral systems [3, 4]. Despite warnings in scientific journals [5], theories that have never been published any specialized journal were widely disseminated by the media and supported political decisions to increased urban mobility and the end of social confinement [3, 4].

This tragic outcome was the result of COVID denialism and associated resistance to social distancing measures, both by individuals and by political leaders. Similar resistance to vaccines after they became available in 2021 would further worsen the pandemic's toll in Brazil. President Jair Bolsonaro and his 2019–2022 administration were responsible for misguided policies and a discourse promoting resistance to effective measures to contain the pandemic [2]. Bolsonaro's actions are credited with at least half a million COVID deaths—75% of Brazil's total by November 2022 [6, 7].

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Fig. 1 **a** Violet (black) indicates the projected (observed) deaths to Manaus. **b** Shows the community use of public transport (busses) in Manaus, compared to the February 2020 baseline. (Data: Ferrante et al. [3])
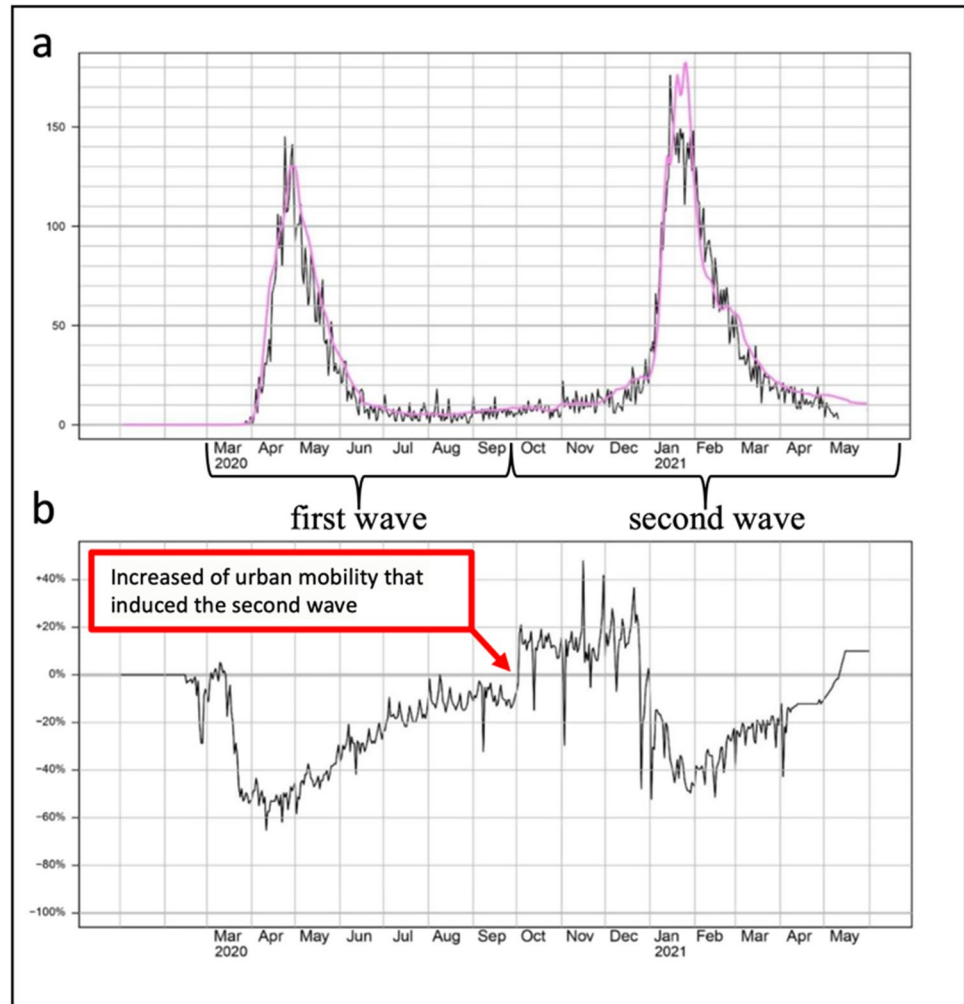
COVID denialism, a hallmark of President Bolsonaro's discourse, was (and still is) strong in Manaus. An indication is provided by the runoff election in October 2022, when 61.3% of the votes for president were for Bolsonaro, the 8th highest among Brazil's 26 state capitals, and both candidates for governor of the state of Amazonas were Bolsonaro supporters. This backdrop reflects the dominant cause of the tragic events in Manaus (and throughout Brazil) stemming from premature reopening of schools and general relaxing of social isolation [3, 4]. A contribution to this outcome came from arguments based on the erroneous suggestion that the pandemic was going to disappear of its own accord.

In May 2020, a hypothesis that the pandemic in Manaus was entering its "last phase" was argued in the 10th newsletter of the Atlas ODS Amazonas group, with the title "*De Epicentro a Redenção: Por que Manaus será a primeira cidade brasileira a vencer a pandemia de COVID-19*" ("From Epicenter to Redemption: Why Manaus will be the first city to beat the COVID-19 pandemic") [8]. The newsletter published by the ODS Amazonas group was created by the first author of the publication and was widely disseminated online through the Federal University of Amazonas (UFAM) website, making it accessible to the entire population of Manaus, including decision-makers and the media. The newsletter in which the information was published is not a scientific journal and is not peer-reviewed. National television networks reported the results as being from a research study indicating that Manaus had entered the final phase of the pandemic (e.g., *Jornal da Record* [9] and *Rede Globo de Televisão* [10]), while some national media reported the same findings together with the fact that these results were questioned by researchers in the area (e.g., *Jornal da Globo* [11] and Maisonnave [12]). Local television in Manaus reported that the reduction in deaths was due to the incidence of a version of the virus that would be less aggressive (*TV A Crítica*, 2020) [13]. According to the newsletter, the reduction in hospitalizations and deaths related to COVID-19 in Manaus in early June 2020 was due to coevolutionary mechanisms of the host-pathogen relationship and certain trade-offs, such as one between virulence and transmission [8]. Here we show that these claims are implausible and lack the necessary support from the scientific literature

and that a rhetoric based on bad science supported the end of social isolation.

Coevolution is the mechanism whereby two or more species reciprocally affect each other's evolution through the process of natural selection [14]. The Atlas ODS Amazonas newsletter argued that "the reductions in severe cases (hospitalizations) and deaths (lethality) […] must be attributed to complex coevolutionary mechanisms of the host-pathogen relationship" [8]. However, a coevolutionary process involving the human species would presuppose the occurrence of a process of natural selection in the human species, which would only be plausible on a timescale of many decades and is thus unrealistic in the case of the new coronavirus SARS-CoV-2.

The newsletter went on to argue that these supposed coevolutionary mechanisms "result from the existence of a 'trade-off' between virulence and transmission and other potential trade-offs, such as between virulence and recovery or between transmission and recovery that have been and continue to be critically underestimated in studies on this and other epidemics and pandemics" [8]. Theories suggesting a virulence-transmission trade-off and other trade-offs exist in the scientific literature, but the empirical evidence so far is only partial [14]. In particular, the occurrence of a trade-off between SARS-CoV-2 virulence and transmission is a hypothesis without any evidence in the scientific literature. Indeed, it is likely that no such trade-off had occurred by June 2020, given the relatively low lethality rate due to infection by the SARS-CoV-2 virus (estimated at around 1%), making it highly questionable that a significant benefit would accrue to the virus if this lethality were to be further

reduced [15]. On the contrary, a process of indirect selection for higher virulence might have been occurring [15]. It would not be possible to affirm the existence of such a virulence-transmission trade-off without a genetic analysis that demonstrates the existence of a new lineage of the virus in Manaus at that time, and there was no evidence to that effect in the scientific literature. A review at that time concluded that it would have been too early for evolutionary processes to have reduced the pathogenicity of the virus in the COVID-19 epidemic [15].

Contrary to the newsletter's assertion that Manaus was entering the last phase of the pandemic in early June 2020, the evidence from two studies by authors of the current paper pointed to a second wave of SARS-CoV-2 infections [5, 16]. Epidemiological data at that time suggested that no European country had seen high enough infection rates to prevent a second wave of transmission if behavioral controls or precautions were to be relaxed without compensatory measures being implemented [17].

On 11 June 2020, the Atlas ODS Amazonas research group published another newsletter [18]. The first figure in the newsletter (reproduced here as Fig. 2) illustrates the result of the logistic equation fitted to the official daily count of deaths from COVID-19 in six state capitals in Brazil's Amazon region. The logistic equation was originally formulated by Verhulst [19] and later independently formulated by Pearl and Reed [20], in both cases to describe human population growth. The equation's assumptions make its application extremely limited (see review in Fearnside, 1986) [21]. Nevertheless, especially in the decade after Pearl and Reed's [20] paper, the logistic equation was applied to a
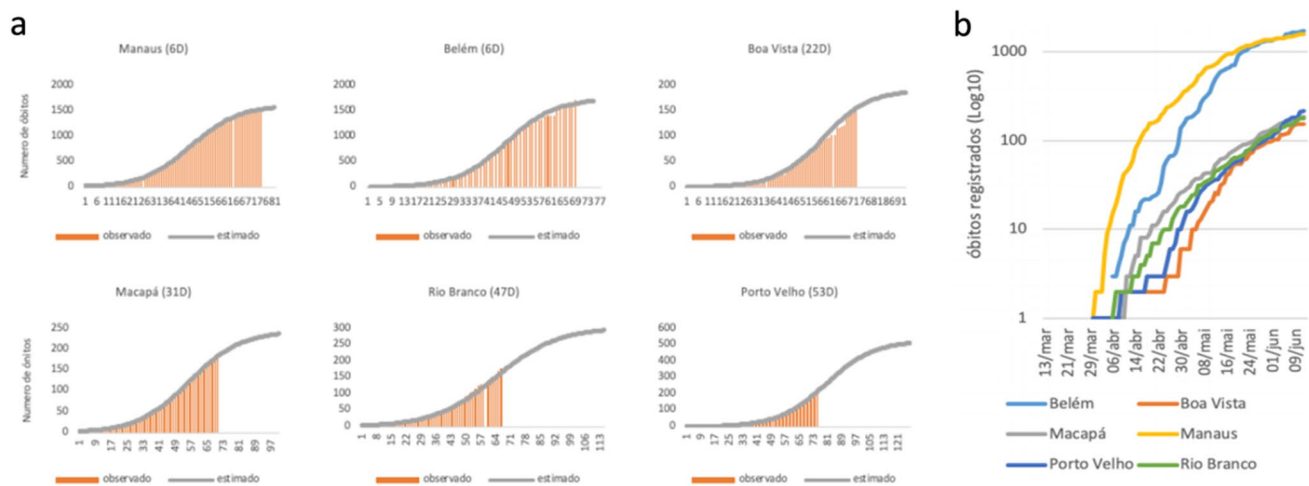

Fig. 2 a This is Figure 1 in Pereira et al. [18]. The graphs of the cumulative number of COVID-19 deaths for Boa Vista, Macapá, Rio Branco, and Porto Velho indicate a tendency for the curve to continue rising, but a gray trend line was added that induces readers to think that the curves will automatically plateau. **b** This is Fig. 2 in Pereira et al. [18]. The authors use the figure to state that the number of daily deaths was slowing in the cities of Belém and Manaus. However, since the y-axis has a logarithmic scale, a decrease in the slope of the death curve does not necessarily mean that the number of daily deaths is slowing

wide variety of biological and social phenomena for which its predictions are invalid [22]. Logistic growth is not a universal law that allows curve fitting to predict the future.

The graphs in Fig. 2a reveal the fragility of the conclusion that the pandemic in Manaus had ended around June 2020. First, it is well known that there was substantial under-reporting of cases and deaths [4, 23]. Because the number of tests in the country as a whole was relatively small, many people developed symptoms and died without being tested. Those who died outside of hospitals were especially likely to not be officially diagnosed and recorded as COVID-19 deaths. Neither the number of cases nor the number of deaths in Brazil had a reliable source, and any scientific study based on these numbers should have included a methodology that allows numerical estimation of this under-reporting, which does not appear to have been done for the results presented in the newsletter.

A second point to note is that various other curves from epidemiological models could be fitted to the data presented in the graphs, but the logistic equation used to generate the gray curves in the graphs do not consider key predictive variables for contact epidemics, such as reinfection rates or increased urban mobility [3, 4], which makes the logistic equation an inadequate analysis.

Moreover, the way in which the gray curves are presented, with a relatively wide line concealing the tops of the bars, could lead readers to conclude that the equation fits the daily death-count data better than it does. This could lead readers to believe that future deaths would follow the logistic extrapolation, for which the authors provide no evidence. In fact, the data for many of the municipalities (counties) had an increasing pattern. The authors claimed that it was possible to deduce from these data the order in which the cities in the study would be able to control the epidemic. However, it is not possible to arrive at conclusions on controlling the epidemic unless the authors can exclude the risk of further waves of infection, which was not argued. Statements suggesting that the epidemic was ending could be expected to lead to wrong decisions both at the personal level and at the level of government policy.

The second newsletter [18] contains another figure, reproduced in Fig. 2b. However, since the y-axis is on a logarithmic scale, the meaning of the shapes of the curves can be deceptive for many readers. A straight line indicates exponential growth, and the slopes of the curves will decrease even when cumulative deaths are increasing at a constant rate. In other words, a decrease in the slope of the death curve when plotted on a logarithmic scale does not necessarily mean that the number of daily deaths is actually slowing down.

Daily deaths in Manaus did, in fact, decrease as a result of social-isolation measures in the final months of the time series considered by the Atlas ODS group in their curve-fitting analysis, but this did not mean that the pandemic had ended and that isolation could be relaxed without consequences, especially at that time when vaccination was not available. The authors of the present paper had predicted a second wave of the pandemic in Manaus [5] based on accepted epidemiological modeling practices [3, 4, 24], and this prediction was borne out by subsequent tragic events. A number of elements were related to the increase in the lethality of COVID-19 in Manaus, including regional inequalities in access to health services; the collapse of the hospital network; misinformation; and negligence of political agents and the general population in the adoption of sanitary measures [3–5, 23, 25].

News of studies that implied that the epidemic had been "beaten" and was drawing to a close was welcome in Manaus and gave local authorities and lobbying groups a justification for relaxing social isolation. The closure of the city's COVID-19 field hospital and the opening of retail stores were presented by the media together with the results from the Atlas ODS newsletter projecting the imminent end to the pandemic in Manaus [26]. Ironically, the Atlas ODS group did not advocate early relaxation of social-distancing restrictions and was a target of those opposing restrictions (e.g., Santos [27]). In light of the subsequent development of the pandemic in Manaus, it is now possible to affirm that such lifting of isolation requirements contributed to the more than of 450 thousand deaths in Brazil (in addition to deaths elsewhere) subsequent to the gamma variant (P.1) first appearing in Manaus, with this variant being responsible for two thirds of COVID-19 deaths in the country [4, 28].

On a national level, on 23 June 2020 President Bolsonaro's minister of health (General Eduardo Pazuello) presented the graphs from the Atlas ODS newsletter (Fig. 2) to the National Congress in a session of the Mixed Commission for Accompanying the Coronavirus, claiming that the data showed that "the tendency is normalcy" and "the curve is almost zero" [29]. This belief may have contributed to the disastrous nature of the Bolsonaro administration's handling of the pandemic throughout Brazil [2].

Public health information played an important role in influencing collective and individual actions seeking protection from the COVID-19 pandemic [30]. It is important to note that misinformation has been used to justify the lack of implementation of restrictive measures to contain the advance of COVID-19 in different places in the world [31–33]. Moreover, questionable news sources have affected the population more strongly in different parts of the world than reliable ones, thus leading to higher indices of community transmission [32, 33].

Monitoring and early action to contain COVID-19 or any other zoonosis is essential to stop a pandemic [34]. Inadequate monitoring or unfounded theories about the remission of an epidemic can be catastrophic, as in the case of Manaus. We believe that questionable scientific practices

contributed to the high number of deaths during the pandemic in Manaus, and, in our view, this could have been avoided, or at least mitigated, by adopting two rather simple guiding principles: (1) sensitive scientific hypotheses should be published in indexed scientific journals; and (2) when reporting on scientific literature, media outlets should seek guidance from scientists who can help distinguishing between reliable journals and gray literature.

Declarations

Ethics Approval Not applicable.

Consent to Participate Not applicable.

Consent for Publication Not applicable.

Competing Interests The authors declare no competing interests.

References

1. López L, Rodó X. The end of social confinement and COVID-19 re-emergence risk. Nat Hum Behav. 2020;4:746–55. https://www.nature.com/articles/s41562-020-0908-8.

2. Federal S. CPI da Pandemia Relatório Final. Brasília: Comissão Parlamentar de Inquérito da Pandemia, Senado Federal; 2022. p. 1080. Available at: https://legis.senado.leg.br/comissoes/comissao?codcol=2441.

3. Ferrante L, et al. Brazil's COVID-19 epicenter in Manaus: how much of the population has already been exposed and are vulnerable to SARS-CoV-2? J Racial Ethn Health Disparities. 2021; https://doi.org/10.1007/s40615-021-01148-8.

4. Ferrante L, et al. Dynamics of COVID-19 in Amazonia: a history of government denialism and the risk of a third wave. Prev Med Rep. 2022;26:101752. https://doi.org/10.1016/j.pmedr.2022.101752.

5. Ferrante L, et al. Brazil's policies condemn Amazonia to a second wave of COVID-19. Nat Med. 2020;26:1315. https://doi.org/10.1038/s41591-020-1026-x.

6. ABRASCO (Associação Brasileira de Saúde Coletiva). Dossiê Abrasco Pandemia de COVID-19. Rio de Janeiro: Abrasco; 2022. p. 314. Available at: https://ss-usa.s3.amazonaws.com/c/308481554/media/1824637bb2d1e9e9d74927413860285/Abrasco_Dossie_Pademia_de_Covid-19_versao2.pdf.

7. de Oliveira C. Os sete erros de Bolsonaro que permitiram 75% das 690 mil mortes por covid no Brasil. Rede Brasil Atual; 2022. Available at: https://www.redebrasilatual.com.br/saude-e-ciencia/sete-erros-bolsonaro-covid-brasil/.

8. Pereira, H. S., Barbosa, D. E. S., Lorenzi, B. C. (2020). De epicentro à redenção: Por que Manaus será a primeira cidade brasileira a vencer a pandemia de COVID-19. Boletim ODS Atlas Amazonas, 2(10), May 2020. Available at: https://riu.ufam.edu.br/bitstream/prefix/5753/5/boletim_ATLAS%20COVID-19%20vol%202%20nr%2010.pdf.

9. Jornal da Record. (2020). Pesquisa indica que Manaus deve ser a 1ª cidade do país a vencer o novo coronavírus. Jornal da Record. Available at: https://www.youtube.com/watch?v=QdyhoTDZrhQ.

10. Rede Globo de Televisão. Coronavírus: Manaus pode ser primeira cidade brasileira a vencer doença. Rede Globo de Televisão. 2020; Available at: https://www.youtube.com/watch?v=CfGkhsICrkQ.

11. da Globo J. Pesquisadores dizem que é cedo para flexibilizar isolamento social no Amazonas. J Globo. 2020; Available at: https://globoplay.globo.com/v/8620722/.

12. Folha de São Paulo. Pesquisadores divergem se Manaus se livrou da epidemia. Folha de São Paulo, 2020. Available at: https://www1.folha.uol.com.br/cotidiano/2020/06/pesquisadores-divergem-se-manaus-se-livrou-da-epidemia.shtml.

13. TV A Crítica. Estudo aponta que Manaus será a primeira cidade a vencer a COVID-19 no país. TV A Crítica; 2020. Available at: https://www.youtube.com/watch?v=Sm1MO8y1M2g.

14. Acevedo MA, Dillemuth FP, Flick AJ, Faldyn MJ, Elderd BD. Virulence-driven trade-offs in disease transmission: a meta-analysis. Evolution. 2019;73(4):636–47. https://doi.org/10.1111/evo.13692.

15. Day T, Gandon S, Lion S, Otto SP. On the evolutionary epidemiology of SARS-CoV-2. Curr Biol. 2020;30:R841–70. https://doi.org/10.1016/j.cub.2020.06.031.

16. Bitar S, Steinmetz WA. Scenarios for the spread of COVID-19 in Manaus, Northern Brazil. Ann Brazilian Acad Scie. 2020;92(4):e20200615. https://doi.org/10.1590/0001-3765202020200615.

17. Okell LC, Verity R, Watson OJ, et al. Have deaths from COVID-19 in Europe plateaued due to herd immunity? Lancet. 2020;395:110–1. https://doi.org/10.1016/S0140-6736(20)31357-X.

18. Pereira HS, Barbosa DES, Lorenzi BC, Vasconcelos ARM. Fases da pandemia em 6 capitais da Amazônia brasileira. Boletim ODS Atlas Amazonas. 2020;2(11) Available at: http://riu.ufam.edu.br/bitstream/prefix/5754/5/boletim_ATLAS%20COVID-19%20vol%202%20nr%2011.pdf.

19. Verhulst PF. Notice sur la loi que la population suit dans son accroissement. Correspondence Mathematique et Physique. 1838;10:113–21.

20. Pearl R, Reed LJ. On the rate of growth of the population of the United States since 1790 and its mathematical representation. Proc Nat Acad Sc USA. 1920;6(8):275–88. https://doi.org/10.1073/pnas.6.6.275.

21. Fearnside PM. Human carrying capacity of the Brazilian rainforest. New York: Columbia University Press; 1986. p. 293.

22. Kingsland S. The refractory model: the logistic curve and the history of population ecology. Q Rev Biol. 1982;57:29–52. https://doi.org/10.1086/412574.

23. Orellana JDY, et al. Excesso de mortes durante a pandemia de COVID-19: subnotificação e desigualdades regionais no Brasil. Cad Saude Publica. 2020;36(1):e00259120.

24. ALEAM. (2020). (Assembleia Legislativa do Estado do Amazonas). Audiência Pública virtual. ALEAM, Manaus, AM, Brazil. Available at: https://www.youtube.com/watch?v=KBZQ6BUEDq8.

25. Barreto ICDHC, et al. Health collapse in Manaus: the burden of not adhering to non-pharmacological measures to reduce the transmission of Covid-19. Saúde Em Debate. 2021;45(131):1126–39. https://doi.org/10.1590/0103-1104202113114I.

26. G1-AM (2020). Hospital de campanha de Manaus encerra atividades após dois meses, e prefeitura fala em redução de novos casos de Covid-19. G1-AM. Available at: https://g1.globo.com/am/amazonas/noticia/2020/06/15/hospital-de-campa

nha-de-manaus-encerra-atividades-apos-dois-meses-e-prefeitura-fala-em-reducao-de-casos-de-covid-19.ghtml.>

27. Santos M. Pesquisador pede suspensão das aulas com dados de junho e julho quando não havia aulas. Portal Marcos Santos. 2020; Available at: https://www.portalmarcossantos.com.br/2020/08/18/pesquisador-pede-suspensao-das-aulas-com-dados-de-junho-e-julho-quando-nao-havia-aulas/.

28. Ferrante L, et al. How Brazil's President turned the country into a global epicenter of COVID-19. J Public Health Policy. 2021;42:439–51. https://doi.org/10.1057/s41271-021-00302-0.

29. Alfaia, I. (2020). Ministro da Saúde anuncia fim do pico do coronavírus no Amazonas. Brasil Norte Comunicação. Available at: https://bncamazonas.com.br/municipios/ministro-saude-anuncia-fim-do-pico-coronavirus-amazonas/.

30. Souza WM, et al. Epidemiological and clinical characteristics of the COVID-19 epidemic in Brazil. Nat Hum Behav. 2020;4:856–65. https://doi.org/10.1038/s41562-020-0928-4.

31. Singh VB. The human costs of COVID-19 policy failures in India. Nat Hum Behav. 2021;5:810–1. https://doi.org/10.1038/s41562-021-01140-6.

32. Merkley E, Loewen PJ. Anti-intellectualism and the mass public's response to the COVID-19 pandemic. Nat Hum Behav. 2021;5:706–15. https://doi.org/10.1038/s41562-021-01112-w.

33. Gravino P, et al. The supply and demand of news during COVID-19 and assessment of questionable sources production. Nat Hum Behav. 2022;6:1069–78. https://doi.org/10.1038/s41562-022-01353-3.

34. Córdoba-Aguilar A, et al. Tackling zoonoses in a crowded world: lessons to be learned from the COVID-19 pandemic. Acta Trop. 2021;214:105780. https://doi.org/10.1016/j.actatropica.2020.105780.