Inductive bases for a possible phenomenology of the global emergence of COVID-19 from the complexity sciences

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ABSTRACT

This text explores the intersection between phenomenology and the sciences of complexity, seeking to understand the dynamics of social interactions during the COVID-19 pandemic. It is argued that the analysis of interactions between individuals, groups and institutions, considering nonlinearities and uncertainties, is fundamental to understand emerging social behaviors. The importance of building a phenomenology of the pandemic that takes into account the social context and the dynamic structures involved is highlighted. Two studies are mentioned: one that analyzes the effectiveness of social distancing in mitigating COVID-19 and another that develops a dynamic model to understand the spread of the disease and vaccination strategies. Both studies highlight the relevance of incorporating the social context into the analyses. The text concludes that understanding the pandemic requires an integrative approach that considers both the complexity of social dynamics and the search for the essence of phenomena. Reflection on controversial topics, such as the use of masks and vaccination, is essential for a more complete analysis of the global COVID-19 emergency, using the tools of complexity sciences to model and understand these dynamic phenomena over time.

Keywords: Phenomenology, Essence, Complexity, Totality, COVID-19.

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INTRODUCTION

In its interdisciplinary approach, the science of complexity encompasses several domains of knowledge, both in relation to the contents of interest and the ways used to represent them. This representation is not limited only to the symbols and vocabulary employed, but is mainly imbued with the intellectual context present during its conception.

Dynamical systems, an integral part of the science of complexity, lack a consensual definition. However, they are composed of units whose behavior, when isolated, is considered simple or predictable, such as convergence to a steady state. However, when these units are coupled, they undergo a more intricate temporal evolution, resulting from the interactions between the parts. In this sense, it is appropriate to examine dynamical systems from the fundamental bases of phenomenology.

Phenomenology is one of the many philosophical currents that developed throughout the twentieth century, especially in the first half. During this period, the main investigations, conjectures and publications on the subject were credited to Husserl (1859-1938). For Husserl, the process of phenomenological induction comprises the following stages (FRAGATA, 1960):

- "Intentional" analysis of the relationship between the object as it is perceived (noema) and its subjective apprehension (noesis). Husserl coined the term "intentional" to describe the relationship between the object and its appearance in the consciousness that perceives it, i.e., its meaning;
- Epoche, which consists of the suspension of the appearances of the world, or of a phenomenon;
- Eidetic reduction (eidos = essence), the process by which essences of a phenomenon are abstracted from consciousness and/or experience, transcending conventional patterns and structures of thought and action to identify their common roots;

Therefore, for Husserl, knowledge resides neither in the observer nor in the observed object, but in the conception or image of the object formulated by the observer. He defines truth as the perfect agreement between the meaning (formulated by the observer) and what is given (the object) (MARCONDES, 2005).

It seems reasonable to us, therefore, to recognize points of convergence between the objectives outlined in the field of complexity sciences, based on dynamic systems, and the methodology that drives phenomenology in its seminal form. Let us look in more detail: It is necessary that the object of study within the natural sciences, including the science of complexity, is nature in its broadest sense, including anthropomorphic relations under certain conditions, even if this nature is expressed through a symbolic set of laws or models, this implies an "intentional" analysis. as mentioned earlier.

In a tangential approach to Sartre (SARTRE, 2021), we can consider the distinction between a "nature in itself" and a "nature for itself". Nature itself represents nature in its intrinsic essence, closed in on itself. On the other hand, nature for itself is that which is revealed by the construction of anthropomorphic consciousness and expressed through laws, equations, models, and narratives. The latter is thus the result of human thought, emerging from eidetic reduction through a reflection on an epoché. Thus, it seeks to constitute processes of repeated interactions where the essence of a phenomenon is sought, rejecting superficial appearances.

It was Marx who stated that "all science would be superfluous if the form of manifestation (the appearance) and the essence of things coincided immediately" (MARX; ALVES, 1983). It was also Marx who affirmed that theory is the real movement of an object transposed to the researcher's brain - it is the real reproduced and interpreted on the ideal plane (of thought). For Marx, the object of research has objective existence; it does not depend on the subject, on the researcher, to exist. The researcher's objective, going beyond the phenomenal, immediate and empirical appearance through which knowledge necessarily begins, this appearance being a level of reality and, therefore, something important and not disposable, is to apprehend the essence (i.e., the **structure and dynamics**) of the object. In a word: the research method that provides theoretical knowledge, starting from appearance, aims to reach the essence of the object, that is: capturing its structure and dynamics (MARX, 2017).

Structure in a dynamic system, an integral part of the sciences of complexity, can be understood as the underlying organization and patterns of interconnection between the various parts or elements that make up the system. It outlines how these elements relate to each other and how their interactions impact the overall behavior of the system over time. This structure encompasses aspects such as the topology of the connections between the elements, the cause-and-effect relationships, the feedback and feedback patterns, as well as the emergence of collective properties. Also part of the structure are the actors, understood here as the research community, and its research agenda, and how it is approached in the face of the multiplicity of options, in view of the available resources and the intellectual emergence of a phenomenon, such as the COVID-19 pandemic.

On the other hand, **dynamics** in a dynamical system refers to the temporal and evolutionary behavior of that system, i.e., how its parts interact and develop over time. It describes the changes, patterns, and processes that occur within the system, and how these changes emerge from the interactions between its components.

In complex systems, dynamics are often characterized by properties such as nonlinearity, interdependence, multiple feedbacks, emergence of patterns, and unpredictable behaviors. These characteristics can result in phenomena such as bifurcations, oscillations, self-organization, chaos, and adaptation.

Now, if in dynamic systems structures are essentially linked to dynamics, and one is not possible without the other, it can be preliminarily concluded that this field of human knowledge meets, at least to a large extent, the driving requirements of phenomenology, being essential to the essence of the phenomena studied by them. However, even if the sciences of complexity are intended for the essence of phenomena, are they also intended for a possible totality of knowledge? Netto teaches us (NETTO, 2009) that it is through abstraction, here understood as intellectual capacity, that an element is extracted from its context. It is then possible to isolate and examine it. Abstraction takes from the abstracted element its most concrete determinations, until it reaches "the simplest determinations". At this level, the abstracted element becomes "abstract" precisely what it is not in the totality from which it was extracted. Here we also come to another observation: knowledge of the essence of an object is not enough; it is necessary to place it in the social context that produced it, if we want to unveil it in its totality (or even totalities, considering that reality, even though it is complex and difficult to grasp, is not fragmented).

It was Martin Heidegger (1889-1976) who, further extending the limits of phenomenology, stated that "a phenomenon is that which shows itself in itself" (HEIDEGGER, 2010). Thus, a phenomenon, when it "shows" itself, does so within a context. Therefore, the essence in phenomenology also requires the context or even the totality worked out by Marx.

At this point, we can already see that the attendance of the driving bases of a possible seminal phenomenology of the COVID-19 pandemic, based on the sciences of complexity, needs to produce structures and dynamics of this pandemic. The plural here is not by chance, as this will necessarily be multifactorial and must be approached from the theoretical multiplicity allowed by the sciences of complexity. At the same time, such structures and dynamics need to reflect the context in which the global emergence of COVID19 unfolded. For this, models, complex networks, etc. (structures) in their temporal evolution (dynamics) need to reflect, at least partially, the context of the COVID-19 pandemic. To this end, some relevance inherent to the global emergency of COVID-19 is presented.

THE COVID-19 EPIDEMIC, ITS CONTEXT AND THE BASIS FOR DYNAMICAL SYSTEMS

At the end of December 2019, patients with pneumonia of unknown origin were reported to the World Health Organization (WHO). All of these cases were associated with the Huanan market, located in the city of Wuhan, China (ZHU et al., 2020). In January, Chinese researchers were able to identify the causative agent of the disease as being a single-stranded, enveloped RNA virus belonging to the Coronaviridae family (LU et al., 2020). Initially called nCoV and 2019-nCoV, the virus was later named SARS-CoV-2, being the cause of Severe Acute Respiratory Syndrome 2 (TAN et al., 2020). On March 11, 2020, after more than 118,000 infected patients in 114 countries and 4291 confirmed deaths, the WHO declared the existence of a global pandemic (WHO, 2020).

Coronaviruses are capable of infecting mammals and birds, causing respiratory, neurological and gastrointestinal diseases (WEISS; LEIBOWITZ, 2011). Before the discovery of SARS-CoV-2, six species of coronaviruses were known to cause disease in humans. Four types of human coronavirus - 229E, OC43, NL63 and HKU1 - are common and usually cause simple cold symptoms in immunocompetent individuals (BOUHEMAD et al., 2011; SU et al., 2016). The other two — the Severe Acute Respiratory Syndrome coronavirus (SARS-CoV) and the Middle East Respiratory Syndrome coronavirus (MERS-CoV) — are zoonotic in origin and have been linked to more severe and potentially fatal illnesses. Due to the high prevalence, wide distribution, great genetic diversity, frequent recombination of their genomes, and increased human-animal interaction, the periodic emergence of new Coronaviruses with the potential to infect humans was predicted (CUI; READ; SHI, 2019).

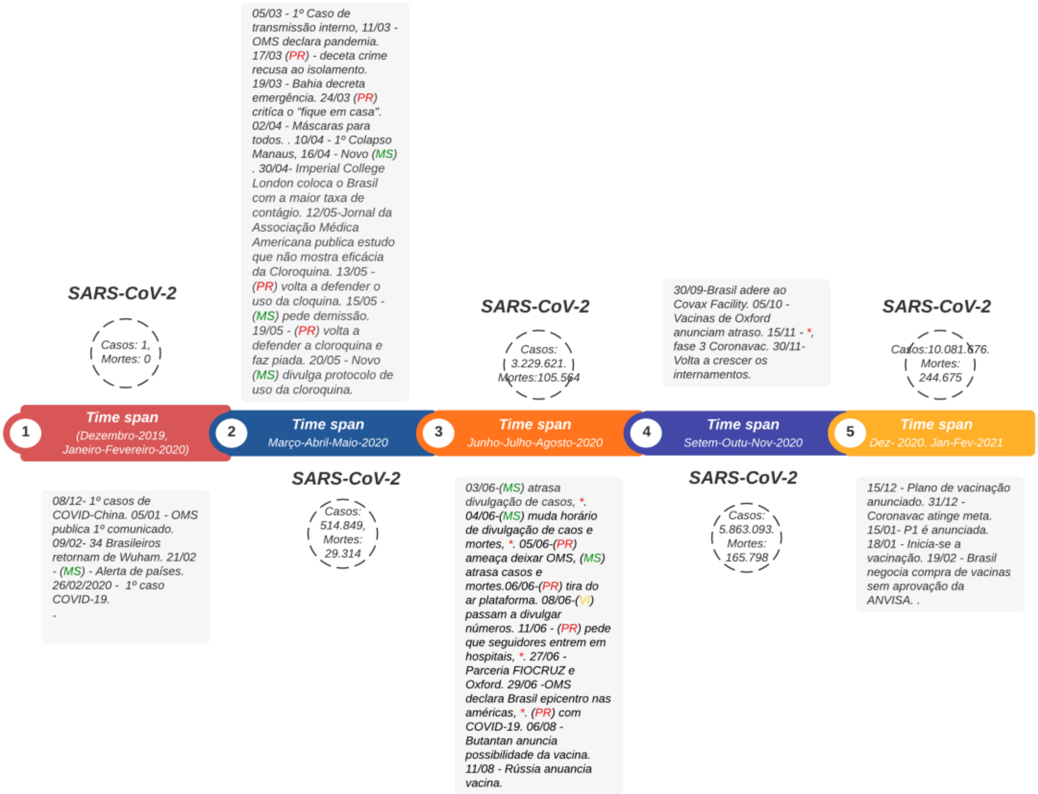
SARS-CoV and MERS-CoV viruses are transmitted by droplets and by direct contact (LEI et al., 2018; OTTER et al., 2016), mechanisms that were initially proposed for the transmission of the new coronavirus, just like its predecessors. Currently, it is known that SARS-CoV-2 is transmitted by respiratory droplets and by a possible, although unlikely, fecal-oral transmission (TAY et al., 2020). There is also the possibility of transmission of the virus also through direct contact with inanimate objects, supported by studies that demonstrated that the virus could remain viable and infectious in aerosol for hours and on surfaces for days (DOREMALEN et al., 2020).

The incubation period of SARS-CoV-2 is estimated at 14 days, with a median of 5 days (LAUER et al., 2020), although this period has changed with the arrival of the omicron variant. The lethality rate of the virus is estimated to be between 0.2 and 1.6%, with large fluctuations between studies. This variation is mainly attributed to the different age groups analyzed and the socioeconomic disparities of the sites studied, including the degree of preparedness of health systems and the proportional number of COVID-19 patients admitted for hospitalization (VERITY et al., 2020; BRAVATA et al., 2021).

In view of the above, it is clear that the spread of SARS-CoV-2 occurs through social interactions, which are subordinated to a political logic. It is no coincidence that a series of metrics of social interactions were produced, the most reported being those prepared by Google (community mobility report) and the Rigor Index produced by the Our World in Data platform. In the case of Google, mobility in leisure places, markets and pharmacies, parks, public transport stations, workplaces and residential places were measured (GOOGLE, 2020). The nine metrics used to calculate the Rigor Index are: school closures; closure of workplaces; cancellation of public events; restrictions on public gatherings; closure of public transport; stay-at-home requirements; public information campaigns; restrictions on internal movements; and international travel control (MATHIEU et al., 2020).

In Brazil, there was an ambiguous approach to confronting SARS-CoV-2. While the majority of municipal and state authorities and the Ministry of Health, at least most of the time, took a position in accordance with the guidance of the majority of the academic community, the presidency of the republic, at various times, verbalized against and did not adhere to the non-pharmacological treatments recommended by the World Health Organization (WHO). In addition, there were verbal and administrative obstacles to the use and acquisition of vaccines. The timeline, figure 1, below illustrates the context in which the COVID-19 emergency unfolded in Brazil (SANAR, 2022). It begins with the first cases of COVID-19 patients in China and is characterized by an escalation of cases and deaths in Brazil. In addition, it is possible to identify two distinct periods of action by public authorities. During the first and second trimesters, approximately, there is a lack of synchrony between the Presidency of the Republic and the Ministry of Health. However, during the third quarter, there is greater political cohesion.

Figure 1: Timeline that encompasses the first year of COVID-19 in Brazil.



"(PR)" refers to the Presidency of the Republic or the President of the Republic. "(MS)" is the abbreviation for Ministry of Health or Minister of Health, and the asterisk (*) indicates a record number of deaths that day.

The continuity of the timeline is shown in figure 2.

Figure 2: Timeline marked by vaccination and drop in deaths.

As evidenced, the second timeline is characterized by an increase in the vaccination rate and an overall improvement in the pandemic situation in Brazil, notably marked by the reduction of COVID-19-related deaths.

In the next section, we address how the science of complexity, notably dynamical systems, has addressed the COVID-19 pandemic.

DYNAMIC MODELS, DISEASES AND THE SEARCH FOR TOTALITY

First of all, it is important to consider the long tradition of complexity sciences in the study of contagious diseases

In its seminal form, it was in 1927 that Kermack and McKendrick proposed a dynamic model known as the SIR (Susceptible, Infected, and Recovered) model, which proposes to describe the spread of an infectious disease (KERMACK; MCKENDRICK, 1927). This model is based on the temporal evolution of compartments that represent the different stages of the population in relation to the disease: susceptible, infected, and recovered. This dynamic is outlined through a system of three differential equations, which describe the migration of individuals between the aforementioned compartments, starting with the susceptible compartment with the introduction of infected individuals. The SIR model has evolved over time to improve the understanding and control of infectious diseases. Several studies have explored the qualitative behavior of the SIR model, analyzing equilibrium points, basic reproduction numbers, and local stability (JACOB et al., 2022; WACKER; SCHLÜTER, 2020). In addition, research has explored discrete SIR models in time with nonlinear incidence and recovery rates, investigating bifurcation properties, such as transcritical bifurcations, period folding and Neimark-Sacker, to enrich theoretical analyses (SADURNÍ; LUNA-ACOSTA, 2021). The examples cited illustrate the evolution of the model proposed by Kermack and McKendrick, showing that its structure, represented by differential equations that describe social interactions, and its dynamics, nonlinear, have been scrutinized and improved over time. Even so, to meet the bases of a possible phenomenology, they need to incorporate the context (totality) and, in the specific case, the context of the COVID-19 pandemic.

As evidence of the intellectual effort of researchers to develop a theory of the pandemic that reflects reality and incorporates the context in which it occurred, we highlight here two works. These studies address aspects that have been the target of social dispute and, based on these, produce conclusions of high relevance for the dynamic description of the COVID-19 pandemic.

The first of them analyzes the impact and effectiveness of social distancing in mitigating the COVID-19 pandemic (FILHO; MORET; MENDES, 2021). In this work, we examine the relationship between SARS-CoV-2 infection rates and a social distancing metric, developed by the authors, based on data from all the most populous states and cities in the United States and Brazil, as well as the 22 countries of the European Economic Community and the United Kingdom. It is also discussed why the infection rate, rather than the actual reproduction number or the case growth rate, is an appropriate choice to perform this analysis when considering a wide period of time. Finally, a strong Spearman rank-order correlation is obtained between the social distancing metric and the infection rate in each locality. In other words, social distancing affects the infection rate. It is important to remember that, as mentioned in the timeline in figure 1, social distancing was the subject of controversy in Brazil, as can be seen in the statements of political authorities. This highlighted work is followed by others with similar themes: (D'ONOFRIO; MANFREDI, 2022; GOUNANE et al., 2021; MAKRIS, 2024), among others.

The second work we highlight (BATISTELA et al., 2023) focuses on the development of a dynamic model, called SIRSI vaccine, to understand the spread of COVID-19 and vaccination strategies. The model considers unreported infectious cases, temporary immunity after infection or vaccination, and the impact of the vaccination rate and the isolation rate on the spread of the disease. The main conclusions and contributions of the study include: the identification of the transcritical bifurcation diagram, showing the stability of endemic and disease-free equilibria based on the vaccination rate and isolation index; the estimation of the maximum number of confirmed cases for different sets of parameters; and the adjustment of the model with data from São Paulo, Brazil, to analyze infected cases and trends in the isolation index. Provides information for policymakers on the effective combination of vaccination and non-pharmaceutical interventions to mitigate the spread of disease. Once again, it is needless to say how controversial the topic of vaccination was in the global emergency of COVID19 here in Brazil. This work is followed by others: (MARINOV; MARINOVA, 2022; AL-RAEEI; EL-DAHER; SOLIEVA, 2021; POONIA et al., 2022), all with similar themes.

Therefore, it becomes evident that the essential understanding of the phenomenon of the COVID-19 pandemic is only achievable through the sciences of complexity, including dynamic systems, if the mathematical framework incorporates the context in which it developed. From these advances, the possibility of a phenomenology of the pandemic through the sciences of complexity arises.

CONCLUSIONS

The profusion of works within the sciences of complexity that seek to incorporate the context of the global emergency of COVID-19 shows us the vocation of this area for such feats. In fact, the purpose of this text was to qualify what we understand to be the inductive bases of a possible phenomenology of the COVID-19 epidemic, based on the sciences of complexity. To this end, we focus on a branch of the sciences of complexity, which are dynamical systems. We glimpse that a phenomenon of nature is apprehended by a researcher from his intellectual activity, converting the phenomenon itself into a phenomenon for himself. In such an act, in order to meet the driving bases of seminal phenomenology, it is necessary for the researcher to get closer to the essence of the object studied. To this end, the structure and dynamics of an object are combined, which, within the sciences of complexity in its branch mentioned here, dynamic systems, are intrinsically intertwined, therefore destined to the essence of the object studied, in this case, the global emergency of COVID-19.

In addition, it was shown to be imperative that the mathematical structure associated with the dynamical system, if it wants to reflect well the reality of what the COVID-19 pandemic was, needs to incorporate the social context in which it unfolded. It is therefore imperative that researchers reflect on controversial topics such as the use of masks, vaccination, social distancing, among others. Due to their characteristics, dynamic systems are suitable for reflecting on such controversies due to their ability to model and analyze complex phenomena that evolve over time, allowing the representation of dynamic behaviors, interactions, and feedbacks between different components of a system. They capture the dynamics of interactions between social agents, such as individuals, groups or institutions, and the consequences of these interactions over time, thus seeking insights into behaviors decided from a political logic. They also incorporate nonlinearities, uncertainties and randomness, reflecting the complexity inherent to social systems. This makes them a powerful tool for understanding and predicting emerging social behaviors, as well as for exploring different scenarios and policies.

By making use of such reflections in their work, and incorporating them into their work, the researchers meet the presuppositions for a possible phenomenology of the COVID-19 pandemic.

Certainly, the construction of a phenomenology of the COVID19 epidemic using the sciences of complexity as a basis, in addition to the assumptions discussed here, needs to consider, analyze and construct a series of other steps. In addition to the search for essence, for example, phenomenology also seeks to identify communalities (SANDERS, 1982), an aspect that has been addressed here only tangentially, and which deserves further reflection.

Investigating the intersection, and imbrication, between the sciences of complexity and phenomenology offers a vast and fruitful field for understanding the multifaceted nature of the phenomena that permeate our world, especially in the COVID-19 epidemic. By adopting an integrative approach that values both the thorough analysis of complex dynamics and the search for the essence and meaning underlying phenomena, we can open up new perspectives and gain deep insights into the reality we have faced throughout the challenging days in which we have found ourselves immersed in the global COVID-19 emergency.

REFERENCES

1. AL-RAEEI, M., EL-DAHER, M. S., & SOLIEVA, O. (2021). Applying SEIR model without vaccination for COVID-19 in case of the United States, Russia, the United Kingdom, Brazil, France, and India. *Epidemiologic Methods, 10*(s1), 20200036.

2. BATISTELA, C. M., CORREA, D. P., BUENO, Á. M., & PIQUEIRA, J. R. C. (2023). SIRSI-vaccine dynamical model for the COVID-19 pandemic. *ISA Transactions, 139*, 391–405.

3. BOUHEMAD, B., LEBRAS, A., MARCHAL, C., & MERHI, Y. (2011). Bedside ultrasound assessment of positive end-expiratory pressure–induced lung recruitment. *American Journal of Respiratory and Critical Care Medicine, 183*(3), 341–347.

4. BRAVATA, D. M., CASSIDY, S., CHUNG, M., & KLEIN, E. (2021). Association of intensive care unit patient load and demand with mortality rates in US Department of Veterans Affairs hospitals during the COVID-19 pandemic. *JAMA Network Open, 4*(1), e2034266.

5. CUI, J., LI, F., & SHI, Z.-L. (2019). Origin and evolution of pathogenic coronaviruses. *Nature Reviews Microbiology, 17*(3), 181–192.

6. D'ONOFRIO, A., & MANFREDI, P. (2022). Behavioral SIR models with incidence-based social-distancing. *Chaos, Solitons & Fractals, 159*, 112072.

7. DOREMALEN, N. V., BUSHMIRE, M., & KRAAY, A. (2020). Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *New England Journal of Medicine, 382*(16), 1564–1567.

8. FILHO, T. M. R., MORET, M. A., & MENDES, J. F. (2021). A transnational and transregional study of the impact and effectiveness of social distancing for COVID-19 mitigation. *Entropy, 23*(11), 1530.

9. FRAGATA, J. (1960). *A fenomenologia de Husserl como fundamento da filosofia*. [Publisher].

10. GOOGLE. (2020). Covid-19: Relatórios de mobilidade da comunidade. Google. Disponível em: [Google link]. Acesso em: 04/05/2024.

11. GOUNANE, S., KHELOUFI, B., & ZAHAF, K. (2021). An adaptive social distancing SIR model for COVID-19 disease spreading and forecasting. *Epidemiologic Methods, 10*(s1), 20200044.

12. HEIDEGGER, M. (2010). *Being and time*. Suny Press.

13. JACOB, S. B., SELVAM, A. G. M., MENAKA, B., & VIANNY, D. A. (2022). Complex dynamics of fractional order SIR model with carrying capacity in discrete time. In *2022 3rd International Conference on Communication, Computing and Industry 4.0 (C2I4)* (pp. 1–6). IEEE.

14. KERMACK, W. O., & MCKENDRICK, A. G. (1927). A contribution to the mathematical theory of epidemics. *Proceedings of the Royal Society of London. Series A, Containing Papers of a Mathematical and Physical Character, 115*(772), 700–721.

15. LAUER, S. A., GRANTZ, K. H., CHUNG, M., WEI, N., & KAGAN, M. (2020). The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: Estimation and application. *Annals of Internal Medicine, 172*(9), 577–582.

16. LEI, H., GUAN, X., WANG, X., & ZHANG, Y. (2018). Routes of transmission of influenza A H1N1, SARS CoV, and norovirus in air cabin: Comparative analyses. *Indoor Air, 28*(3), 394–403.

17. LU, R., ZHAO, X., ZHANG, L., & JIANG, S. (2020). Genomic characterisation and epidemiology of 2019 novel coronavirus: Implications for virus origins and receptor binding. *The Lancet, 395*(10224), 565–574.

18. MAKRIS, M. (2024). COVID and social distancing with a heterogeneous population. *Economic Theory, 77*(1), 445–494.

19. MARCONDES, D. (2005). *A pragmática na filosofia contemporânea* (Vol. 59). Zahar.

20. MARINOV, T. T., & MARINOVA, R. S. (2022). Adaptive SIR model with vaccination: Simultaneous identification of rates and functions illustrated with COVID-19. *Scientific Reports, 12*(1), 15688.

21. MARX, K. (2017). *Miséria da filosofia*. Boitempo Editorial.

22. MARX, K., & ALVES, M. H. B. (1983). *Contribuição à crítica da economia política* (Vol. 2). Martins Fontes.

23. MATHIEU, E., RUTKOWSKI, A., & GONG, J. (2020). Coronavirus pandemic (COVID-19). *Our World in Data*. Disponível em: www.ourworldindata.org/coronavirus. Acesso em: 02/05/2024.

24. NETTO, J. P. (2009). Introdução ao método da teoria social. In *Serviço Social: Direitos sociais e competências profissionais* (pp. 668–700). CFESS/ABEPSS.

25. OTTER, J. A., YATES, S., & HUGHES, C. (2016). Transmission of SARS and MERS coronaviruses and influenza virus in healthcare settings: The possible role of dry surface contamination. *Journal of Hospital Infection, 92*(3), 235–250.

26. POONIA, R. C., ANTONY, S., & DOLIN, R. (2022). An enhanced SEIR model for prediction of COVID-19 with vaccination effect. *Life, 12*(5), 647.

27. SADURNÍ, E., & LUNA-ACOSTA, G. (2021). Exactly solvable SIR models, their extensions and their application to sensitive pandemic forecasting. *Nonlinear Dynamics, 103*, 2955–2971.

28. SANAR. (2022). Linha do tempo do Coronavírus no Brasil. Disponível em: www.sanarmed.com/linha-do-tempo-do-coronavirus-no-brasil. Acesso em: 03/05/2024.

29. SANDERS, P. (1982). Phenomenology: A new way of viewing organizational research. *Academy of Management Review, 7*(3), 353–360.

30. SARTRE, J.-P. (2021). *O ser e o nada*. Leya.

31. SU, S., LEE, H., & YUAN, J. (2016). Epidemiology, genetic recombination, and pathogenesis of coronaviruses. *Trends in Microbiology, 24*(6), 490–502.

32. TAN, W., ZHANG, J., & WANG, L. (2020). A novel coronavirus genome identified in a cluster of pneumonia cases—Wuhan, China 2019-2020. *China CDC Weekly, 2*(4), 61–62.
33. TAY, M. Z., POH, C. M., RÉNIA, L., MACARY, P. A., & NG, L. F. (2020). The trinity of COVID-19: Immunity, inflammation and intervention. *Nature Reviews Immunology, 20*(6), 363–374.

34. VERITY, R., OKELL, L. C., DORSEY, C., & WANG, H. (2020). Estimates of the severity of coronavirus disease 2019: A model-based analysis. *The Lancet Infectious Diseases, 20*(6), 669–677.

35. WACKER, B., & SCHLÜTER, J. (2020). Time-continuous and time-discrete SIR models revisited: Theory and applications. *Advances in Difference Equations, 2020*(1), 556.

36. WEISS, S. R., & LEIBOWITZ, J. L. (2011). Coronavirus pathogenesis. *Advances in Virus Research, 81*, 85–164.

37. WHO. (2020). *WHO Director-General's opening remarks at the media briefing on COVID-19 - 11 March 2020*. Disponível em: [WHO Director-General's opening remarks](https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020). Acesso em: 20/04/2024.

38. ZHU, N., ZHANG, D., WANG, W., & LI, X. (2020). A novel coronavirus from patients with pneumonia in China, 2019. *New England Journal of Medicine, 382*(8), 727–733.