

José Salvador da
Motta Reis
Dayana Elizabeth
Werderits Silva
Gilberto Santos¹
Luís César Ferreira
Motta Barbosa

Article info:

Received 13.09.2024.
Accepted 02.04.2025.

DOI – 10.24874/IJQR19.04-13



THE PATHS TAKEN BY SCIENTIFIC RESEARCH AFTER THE COVID-19 PANDEMIC TOWARDS BETTER QUALITY OF LIFE

Abstract: *Given the complexity and continuous evolution of the COVID-19 pandemic, it is essential to carry out a comprehensive update of the state of the art in publications on the subject. Almost four years after the start of the pandemic, the scientific landscape has changed substantially, with a significant number of new studies and discoveries. In this context, the research proposes to deepen the analysis method by implementing new comparative metrics, as well as expanding the results to provide a more comprehensive and accurate view of the accumulated knowledge on COVID-19, towards better quality of life. This effort aims to provide an up-to-date and in-depth understanding of trends, advances, and gaps in the scientific literature, thus contributing to better management and decision-making in relation to the pandemic.*

Keywords: *pandemic, public health, global sustainability, virus.*

1. Introduction

The Sars-CoV-2 pandemic in the year 2020, initially discovered in China, in Wuhan, with the first cases reported in 2019, primarily affected individuals who were in contact with the Huanan Seafood Wholesale Market (Franco et al., 2022; Xu et al., 2020; F. Zhou et al., 2020a). Despite a wide range of transmissions, these do not represent the first occurrences of this virus. Since 2002, research has been conducted to identify cases of individuals with acute respiratory disorders caused by the so-called Sars-CoV. Furthermore, in 2012, similar episodes involving the Bat-Sars-CoV occurred, which were identified as Mers-CoV (Ackermann et al., 2020; Lauer et al., 2020; Nicola et al., 2020).

The outbreaks of 2002 and 2012 resulted in numerous cases of infection and deaths,

triggering a large-scale epidemic scenario in the Arabian Peninsula. However, it is important to emphasize that asymptomatic infections can spread the virus, which prompted the suggestion of social isolation during the Sars-CoV outbreak (Bavel et al., 2020). The main symptoms presented by patients affected by this new virus include fever, dry cough, along with some cases of diarrhea, nausea, and vomiting. Nevertheless, respiratory symptoms and signs were the primary indicators of the disease (Beigel et al., 2020; J. S. D. M. Reis et al., 2020; Xu et al., 2020).

Despite a wide range of transmissions, these do not represent the first occurrences of this virus. Since 2002, research has been conducted to identify cases of individuals with acute respiratory disorders caused by the so-called Sars-CoV. Furthermore, in 2012, similar episodes involving the Bat-Sars-CoV

¹ Corresponding author: Gilberto Santos
Email: gsantos@ipca.pt

occurred, which were identified as Mers-CoV (Bavel et al., 2020; Shi et al., 2020; Xiong et al., 2020). The outbreaks of 2002 and 2012 resulted in numerous cases of infection and deaths, triggering a large-scale epidemic scenario in the Arabian Peninsula. However, it is important to emphasize that asymptomatic infections can spread the virus, which prompted the suggestion of social isolation during the Sars-CoV outbreak (Beigel et al., 2020; Nicola et al., 2020; Xiong et al., 2020).

The main symptoms presented by patients affected by this new virus include fever, dry cough, and in some cases, diarrhea, nausea, and vomiting. However, respiratory symptoms and signs were the primary indicators of the disease (Bavel et al., 2020; Y. Dong et al., 2020a; Qiu et al., 2020).

In this context, the research proposes to deepen the analysis method by implementing new comparative metrics, as well as expanding the results to provide a more comprehensive and accurate view of the accumulated knowledge on COVID-19.

2. Theoretical framework

At the beginning of the 21st century, the SARS-CoV-1 epidemic emerged in 2002, followed by the MERS-CoV epidemic in 2012. SARS-CoV-2 represents the third affliction belonging to the same viral family over the last two decades. The SARS-CoV-2 outbreak, responsible for the Covid-19 disease, began in Wuhan in 2019 and was promptly designated as a pandemic by the World Health Organization (WHO) on March 11, 2020 (Ji et al., 2020; Liu et al., 2020; Reis et al., 2020).

To confront the challenges posed by the epidemic, health professionals and researchers have adopted various technologies. Studies are underway to explore alternatives based on deep learning models to detect Covid-19 in CT images and accurately differentiate possible cases of pneumonia (Cerullo et al., 2020; Cohen et al., 2020; Zhao

J. et al., 2020).

Despite the significant range of transmissions, these are not the first cases of this virus. It should be noted that since 2002. However, asymptomatic infections can spread the virus, which is why social isolation was also suggested in the Sars-CoV outbreak. The main symptoms presented by this new virus in patients were: fever, dry cough, some had diarrhea, nausea and vomiting (Guo et al., 2020; Rogers et al., 2020; Vindegaard & Benros, 2020).

Covid-19 has led to significant changes in the way people live, work and interact, forcing society to redesign life in public spaces, particularly in closed environments such as: homes, workplaces, public facilities and workplaces (Khan et al., 2020; Taubenberger et al., 2020; Reis et al., 2020; Zhao Q. et al., 2020).

Health and hygiene at work, as well as respect for environmental rules were very important in these difficult times (Silva et al., 2022; Teixeira et al., 2022; Silva et al., 2020; Talapatra et al., 2022; Santos et al., 2014; Craveiro et al., 2023), namely, to improve society (Santos et al., 2019; Vieira et al., 2019 ; Sun et al., 2013 ; Yülek & Santos, 2022 ; Santos & Millán, 2013).

According to information released by the World Health Organization, as of April 18, the number of people officially infected with COVID-19 was approximately 2,160,207, and the total number of deaths was approximately 146,088 (Ji et al., 2020; Liu et al., 2020; Reis et al., 2020).

The speed of medical diagnosis is key to quickly isolating and treating infected patients and preventing the spread of the virus. This concern about a virus about which the science is poorly understood is reflected in the large number of documents produced and made available on the Internet and in the main academic databases (Beuermann, et al., 2024; Ishiguro et al., 2024; Sevinc Ozdemir et al., 2024).

3. Scientific method

The research falls into the category of applied exploratory with a quantitative approach. The method and technical procedures employed consist of bibliographic research and literature (Table 1) (Espuny et al., 2021;

Kothari & Garg, 2019).

The research was structured in five stages. These stages are illustrated in Figure 1, in the following order: problem definition, data collection, literature review, data treatment in the light of the literature and final drafting of the article.

Table 1. Research classification. Adapted from Barbosa et al. (2023); Espuny et al. (2022); Kothari and Garg (2019).

Nature	Objective	Approach	Research procedures
Basic	Exploratory	Quantitative	Experiment
Applied	Descriptive	Qualitative	Survey
	Explanatory	Combined	Bibliometric study
	Normative		Modeling
			Case study
			Simulation

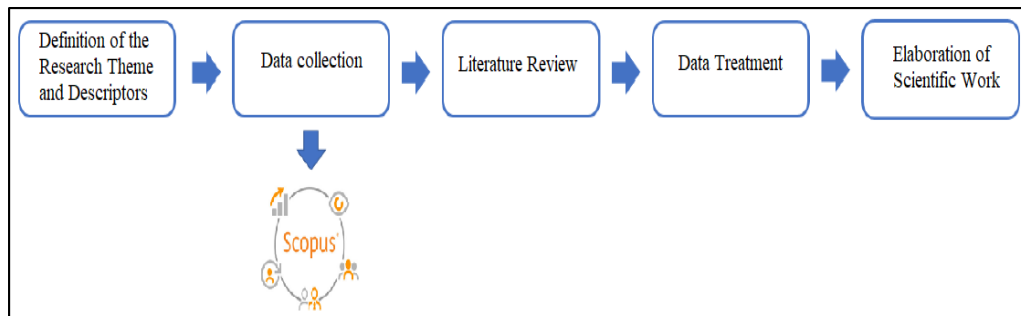


Figure 1. Methodological Flow. Adapted from Espuny et al. (2022); Reis et al. (2021).

To achieve the objectives of this research, a new analysis was carried out of the 20 most cited articles on the pandemic on April 4, 2024. After this analysis, the scientific gaps were identified and then a comparison was made of research trends on the subject in the pandemic and post-pandemic scenarios, to understand the paths of science in relation to the COVID-19 pandemic between the years 2020 and 2024.

Initially, articles with the descriptor "COVID-19" in the title were identified in a search of the Scopus database, and only those published in English were considered, as it is the language most commonly used in science

(Nunhes & Oliveira, 2018). A total of 363215 articles were published between 2019 and 2024. Among these, 20 were selected with the highest number of citations.

4. Results and discussions

According to Table 2, the 20 scientific gaps (in the year 2020) were grouped into 6 clusters, according to the similarity presented by each study.

According to Table 3, the 20 scientific gaps (in the year 2024) were grouped into 3 clusters, according to the similarity presented by each study.

Table 2. Scientific gaps in the Covid-19 theme in 2020. Adapted from Reis et al. (2020).

#	Scientific Gap	Reference
1	Regulation of the wild animal market	Chen et al. (2020c); Zhou P. et al. (2020a)
2	Traceability of COVID-19	Chan et al. (2020a); Huang et al. (2020); Ji et al. (2020); Lu R. et al. (2020); Wan et al. (2020); Wu et al. (2020)
3	Detection of COVID-19	Holshue et al. (2020); Zhu et al. (2020)
4	Prevention of COVID-19	Chan et al. (2020b); Wu and McGoogan (2020); Xu et al. (2020)
5	Impacts of COVID-19 on patients	Backer et al. (2020); Chen H. et al. (2020a); Chen N. et al. (2020b); Chung et al. (2020c)
6	The proposition of vaccines, treatment, and cure of COVID-19	Lu H. (2020); Munster et al. (2020); Wang et al. (2020a)

Table 3. Scientific gaps in the Covid-19 theme in 2024.

#	Scientific Gap	Reference
1	Treatment and prevention of COVID-19	Beigel et al. (2020); Gautret et al. (2020); Horby et al. (2021); Polack et al. (2020)
2	Pathological investigations of COVID-19 in patients	Ackermann et al. (2020); Ai et al., (2020); Cao et al. (2020); Dong et al. (2020b); Lai et al. (2020); Lauer et al. (2020); Mehta et al. (2020); Richardson et al. (2020); Varga et al. (2020); Williamson et al. (2020); Xu et al. (2020); Zhou et al. (2020b)
3	Socio-economic impacts of COVID-19	Cucinotta and Vanelli (2020); Nicola et al. (2020); Wang et al. (2020b); Wu and McGoogan (2020)

The scientific gaps carried out in 2020 and 2024 address different aspects related to the development and mitigation of the COVID-19 pandemic, but there are some distinctions between them. The 2020 analysis focuses more on the regulatory and scientific aspects of the pandemic. It discusses the regulation of the wildlife market, which is crucial to prevent future zoonotic pandemics. In addition, it talks about the traceability of the virus, its detection, prevention, and the direct impacts on affected patients.

It also mentions proposed vaccines, treatments, and cures for COVID-19. The 2024 analysis focuses more on COVID-19 treatment and prevention measures, including pathological investigations on affected patients. It also addresses the socio-economic impacts of the pandemic, which have been significant worldwide.

One notable difference is that the 2020 analysis includes broader issues, such as the regulation of the wildlife market, while the 2024 analysis is more focused on the direct clinical and socio-economic aspects of the

disease. Both groups are equally important for understanding and dealing with the pandemic comprehensively. As for the similarities of the two analyses, both are focused on aspects of preventing the COVID-19 pandemic and its ramifications in different areas.

Prevention and treatment of COVID-19, in the 2020 and 2024 analysis address aspects related to the prevention and treatment of COVID-19. While 2024 focuses more specifically on these topics, Group 1 also mentions them as part of the essential measures to deal with the pandemic. Impacts of COVID-19, both analyses describe the impacts of COVID-19, although they are approached in different ways. The 2020 analysis addresses direct impacts on affected patients, while Group 2 explores the socio-economic impacts of the pandemic more broadly.

Pathological investigations in 2020 and 2024 include discussions on pathological investigations related to COVID-19 in patients. This demonstrates a shared concern

with understanding the clinical and biological aspects of the disease. Finally, there are proposals for vaccines and treatments: Both groups mention the importance of proposals for vaccines, treatments and cures for COVID-19.

This reflects the global search for effective medical solutions to contain the pandemic. Although the analyses approach these topics in slightly different ways, their similarities highlight the scope and complexity of the COVID-19 pandemic and the need for multidisciplinary approaches to tackle it effectively.

5. Conclusion

The study presented an overview of scientific production on COVID-19. This overview was structured in two parts, an analysis of the output from 2020 and 2024. The objective of analyzing the changes in the scientific scenario on COVID-19 was achieved, as the scientific gaps were concluded at both times. The great novelty lies in the identification of the scientific gaps in 2024 and the comparative analysis between the scientific gaps of 2020 and 2024. In 2020, the analysis was largely focused on the detection, prevention and direct treatment of COVID-19, as well as the regulation of the wildlife market as a preventative measure. The focus on traceability of the virus and proposals for vaccines and treatments was also prominent, reflecting the urgency of containing the spread of the disease and mitigating its

impacts. By 2024, on the other hand, the analysis shows a shift in emphasis.

While the continuity of discussions on treatment and prevention of COVID-19 is evident, there is a significant expansion to pathological investigations in patients and to the socio-economic impacts of the pandemic. This suggests an evolution in the understanding of the disease, moving from a more direct approach to a more comprehensive view that considers not only physical health, but also the social and economic consequences of the health crisis. The change in focus reflects the continuous learning and adaptation of strategies to deal with the pandemic over time. As more scientific information has been obtained and the pandemic has evolved, the areas of interest and concern have broadened to cover a wider range of aspects related to COVID-19, beyond immediate containment and treatment measures. This highlights the importance of continuous analysis and flexibility in scientific approaches to effectively deal with constantly evolving public health challenges. As a proposal for future studies, a quantitative analysis by subject area within the COVID-19 macro-group is pending, to make a detailed map of the concentration of research and money invested.

Acknowledgment: This study was funded by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES) - Financial Code 001.

References:

- Ackermann, M., Verleden, S. E., Kuehnel, M., Haverich, A., Welte, T., Laenger, F., ... Jonigk, D. (2020). Pulmonary Vascular Endothelialitis, Thrombosis, and Angiogenesis in Covid-19. *New England Journal of Medicine*, 383(2), 120–128. <https://doi.org/10.1056/NEJMoa2015432>
- Ai, T., Yang, Z., Hou, H., Zhan, C., Chen, C., Lv, W., ... Xia, L. (2020). Correlation of Chest CT and RT-PCR Testing for Coronavirus Disease 2019 (COVID-19) in China: A Report of 1014 Cases. *Radiology*, 296(2), E32–E40. <https://doi.org/10.1148/radiol.2020200642>

- Backer, J. A., Klinkenberg, D., & Wallinga, J. (2020). Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travellers from Wuhan, China, 20–28 January 2020. *Eurosurveillance*, 25(5). <https://doi.org/10.2807/1560-7917.ES.2020.25.5.2000062>
- Barbosa, L. C. F. M., Reis, J. S. da M., Mathias, M. A. S., Oliveira, O. J. de, Juliani, F., & Santos, G. (2023). Principles of Business Strategy: Towards a Holistic View. *Proceedings on Engineering Sciences*, 5(4), 679–692. <https://doi.org/10.24874/PES05.04.010>
- Bavel, J. J. Van, Baicker, K., Boggio, P. S., Capraro, V., Cichocka, A., Cikara, M., ... Willer, R. (2020). Using social and behavioural science to support COVID-19 pandemic response. *Nature Human Behaviour*, 4(5), 460–471. <https://doi.org/10.1038/s41562-020-0884-z>
- Beigel, J. H., Tomashek, K. M., Dodd, L. E., Mehta, A. K., Zingman, B. S., Kalil, A. C., ... Lane, H. C. (2020). Remdesivir for the Treatment of Covid-19 — Final Report. *New England Journal of Medicine*, 383(19), 1813–1826. <https://doi.org/10.1056/NEJMoa2007764>
- Beuermann, D. W., Botton, N. L., Hoffmann, B., Jackson, C. K., & Vera-Cossio, D. (2024). Does education prevent job loss during downturns? Evidence from exogenous school assignments and COVID-19 in Barbados. *European Economic Review*, 162, 104675. <https://doi.org/10.1016/j.euroecorev.2024.104675>
- Cao, B., Wang, Y., Wen, D., Liu, W., Wang, J., Fan, G., Wang, C. (2020). A Trial of Lopinavir–Ritonavir in Adults Hospitalized with Severe Covid-19. *New England Journal of Medicine*, 382(19), 1787–1799. <https://doi.org/10.1056/NEJMoa2001282>
- Cerullo, G., Negro, M., Parimbelli, M., Pecoraro, M., Perna, S., Liguori, G., D’Antona, G. (2020). The Long History of Vitamin C: From Prevention of the Common Cold to Potential Aid in the Treatment of COVID-19. *Frontiers in Immunology*, 11. <https://doi.org/10.3389/fimmu.2020.574029>
- Chan, J. F.-W., Kok, K.-H., Zhu, Z., Chu, H., To, K. K.-W., Yuan, S., & Yuen, K.-Y. (2020a). Genomic characterization of the 2019 novel human-pathogenic coronavirus isolated from a patient with atypical pneumonia after visiting Wuhan. *Emerging Microbes & Infections*, 9(1), 221–236. <https://doi.org/10.1080/22221751.2020.1719902>
- Chan, J. F.-W., Yuan, S., Kok, K.-H., To, K. K.-W., Chu, H., Yang, J., Yuen, K.-Y. (2020b). A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *The Lancet*, 395(10223), 514–523. [https://doi.org/10.1016/S0140-6736\(20\)30154-9](https://doi.org/10.1016/S0140-6736(20)30154-9)
- Chen, H., Guo, J., Wang, C., Luo, F., Yu, X., Zhang, W., Zhang, Y. (2020a). Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. *The Lancet*, 395(10226), 809–815. [https://doi.org/10.1016/S0140-6736\(20\)30360-3](https://doi.org/10.1016/S0140-6736(20)30360-3)
- Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., Zhang, L. (2020b). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *The Lancet*, 395(10223), 507–513. [https://doi.org/10.1016/S0140-6736\(20\)30211-7](https://doi.org/10.1016/S0140-6736(20)30211-7)
- Chen, Y., Liu, Q., & Guo, D. (2020c). Emerging coronaviruses: Genome structure, replication, and pathogenesis. *Journal of Medical Virology*, 92(4), 418–423. <https://doi.org/10.1002/jmv.25681>
- Chung, M., Bernheim, A., Mei, X., Zhang, N., Huang, M., Zeng, X., Shan, H. (2020). CT Imaging Features of 2019 Novel Coronavirus (2019-nCoV). *Radiology*, 295(1), 202–207. <https://doi.org/10.1148/radiol.2020200230>

- Cohen, P. A., Hall, L. E., John, J. N., & Rapoport, A. B. (2020). The Early Natural History of SARS-CoV-2 Infection. *Mayo Clinic Proceedings*, 95(6), 1124–1126. <https://doi.org/10.1016/j.mayocp.2020.04.010>
- Craveiro, A., Lima, V., Santos, G., Sá, J.C., Lopes, M., Carvalho, J.D. (2023). Lean and Six Sigma Philosophies and Organizational Performance: A Study in Portuguese Laboratories. *Quality Innovation Prosperity Journal* 27 (1), 21-45. doi: 10.12776/QIP.V27I1.1802
- Cucinotta, D., & Maurizio Vanelli. (2020). WHO Declares COVID-19 a Pandemic. *Acta Biomed*, 91(1), 157–160. <https://doi.org/10.23750/abm.v91i1.9397>
- Dong, E., Du, H., & Gardner, L. (2020a). An interactive web-based dashboard to track COVID-19 in real time. *The Lancet Infectious Diseases*, 20(5), 533–534. [https://doi.org/10.1016/S1473-3099\(20\)30120-1](https://doi.org/10.1016/S1473-3099(20)30120-1)
- Dong, Y., Mo, X., Hu, Y., Qi, X., Jiang, F., Jiang, Z., & Tong, S. (2020b). Epidemiology of COVID-19 Among Children in China. *Pediatrics*, 145(6). <https://doi.org/10.1542/peds.2020-0702>
- Espuny, M., Costa, A. C. F., Reis, J. S. da M., Barbosa, L. C. F. M., Carvalho, R., Santos, G., & Oliveira, O. J. de. (2022). Identification of the Elements and Systematisation of the Pillars of Solid Waste Management. *Quality Innovation Prosperity*, 26(2), 147–169. <https://doi.org/10.12776/qip.v26i2.1717>
- Espuny, M., Faria Neto, A., Reis, J. S. da M., dos Santos Neto, S. T., Nunhes, T. V., & Oliveira, O. J. de. (2021). Building New Paths for Responsible Solid Waste Management. *Environmental Monitoring and Assessment*, 193(7), 442. <https://doi.org/10.1007/s10661-021-09173-0>
- Franco, J. de A. B., Espuny, M., Reis, J. S. da M., Diogo, G. M. M., Nunhes, T. V., Barbosa, L. C. F. M., ... Oliveira, O. J. de. (2022). Digital Transformation in School Management: The Legacy that Strategic Actions in the 2020s Leave for Future Pandemics. *Gestão & Produção*, 29(1), 1–22. <https://doi.org/10.1590/1806-9649-2022v29e622>
- Gautret, P., Lagier, J.-C., Parola, P., Hoang, V. T., Meddeb, L., Mailhe, M., ... Raoult, D. (2020). Hydroxychloroquine and azithromycin as a treatment of COVID-19: results of an open-label non-randomized clinical trial. *International Journal of Antimicrobial Agents*, 56(1), 105949. <https://doi.org/10.1016/j.ijantimicag.2020.105949>
- Guo, Y.-R., Cao, Q.-D., Hong, Z.-S., Tan, Y.-Y., Chen, S.-D., Jin, H.-J., ... Yan, Y. (2020). The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak – an update on the status. *Military Medical Research*, 7(1), 11. <https://doi.org/10.1186/s40779-020-00240-0>
- Holshue, M. L., DeBolt, C., Lindquist, S., Lofy, K. H., Wiesman, J., Bruce, H., Pillai, S. K. (2020). First Case of 2019 Novel Coronavirus in the United States. *New England Journal of Medicine*, 382(10), 929–936. <https://doi.org/10.1056/NEJMoa2001191>
- Horby, P., Lim, W. S., Emberson, J. R., Mafham, M., Bell, J. L., Linsell, L., Landray, M. J. (2021). Dexamethasone in Hospitalized Patients with Covid-19. *New England Journal of Medicine*, 384(8), 693–704. <https://doi.org/10.1056/NEJMoa2021436>
- Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., ... Cao, B. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *The Lancet*, 395(10223), 497–506. [https://doi.org/10.1016/S0140-6736\(20\)30183-5](https://doi.org/10.1016/S0140-6736(20)30183-5)
- Ishiguro, T., Kobayashi, Y., Shimizu, Y., Uemura, Y., Toriba, R., Takata, N., Shimizu, Y. (2024). Prognostic factors of virus-associated pneumonia other than COVID-19 in adults. *Respiratory Medicine*, 221, 107497. <https://doi.org/10.1016/j.rmed.2023.107497>

- Ji, W., Wang, W., Zhao, X., Zai, J., & Li, X. (2020). Cross-species transmission of the newly identified coronavirus 2019-nCoV. *Journal of Medical Virology*, 92(4), 433–440. <https://doi.org/10.1002/jmv.25682>
- Khan, M., Adil, S. F., Alkathlan, H. Z., Tahir, M. N., Saif, S., Khan, M., & Khan, S. T. (2020). COVID-19: A Global Challenge with Old History, Epidemiology and Progress So Far. *Molecules*, 26(1), 39. <https://doi.org/10.3390/molecules26010039>
- Kothari, C. R., & Garg, G. (2019). Research methodology methods and techniques. In *New Age International* (4^o). Nova Deli: New Age International.
- Lai, C.-C., Shih, T.-P., Ko, W.-C., Tang, H.-J., & Hsueh, P.-R. (2020). Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): The epidemic and the challenges. *International Journal of Antimicrobial Agents*, 55(3), 105924. <https://doi.org/10.1016/j.ijantimicag.2020.105924>
- Lauer, S. A., Grantz, K. H., Bi, Q., Jones, F. K., Zheng, Q., Meredith, H. R., Lessler, J. (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. <https://doi.org/10.7326/M20-0504>
- Liu, Y.-C., Kuo, R.-L., & Shih, S.-R. (2020). COVID-19: The first documented coronavirus pandemic in history. *Biomedical Journal*, 43(4), 328–333. <https://doi.org/10.1016/j.bj.2020.04.007>
- Lu, H. (2020). Drug treatment options for the 2019-new coronavirus (2019-nCoV). *BioScience Trends*, 14(1), 69–71. <https://doi.org/10.5582/bst.2020.01020>
- Lu, R., Zhao, X., Li, J., Niu, P., Yang, B., Wu, H., Tan, W. (2020). Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. *The Lancet*, 395(10224), 565–574. [https://doi.org/10.1016/S0140-6736\(20\)30251-8](https://doi.org/10.1016/S0140-6736(20)30251-8)
- Mehta, P., McAuley, D. F., Brown, M., Sanchez, E., Tattersall, R. S., & Manson, J. J. (2020). COVID-19: consider cytokine storm syndromes and immunosuppression. *The Lancet*, 395(10229), 1033–1034. [https://doi.org/10.1016/S0140-6736\(20\)30628-0](https://doi.org/10.1016/S0140-6736(20)30628-0)
- Munster, V. J., Koopmans, M., van Doremalen, N., van Riel, D., & de Wit, E. (2020). A Novel Coronavirus Emerging in China — Key Questions for Impact Assessment. *New England Journal of Medicine*, 382(8), 692–694. <https://doi.org/10.1056/NEJMp2000929>
- Nicola, M., Alsafi, Z., Sohrabi, C., Kerwan, A., Al-Jabir, A., Iosifidis, C., Agha, R. (2020). The socio-economic implications of the coronavirus pandemic (COVID-19): A review. *International Journal of Surgery*, 78, 185–193. <https://doi.org/10.1016/j.ijisu.2020.04.018>
- Nunhes, T. V., & Oliveira, O. J. (2018). Analysis of Integrated Management Systems research: identifying core themes and trends for future studies. *Total Quality Management & Business Excellence*, 31(11–12), 1243–1265. <https://doi.org/10.1080/14783363.2018.1471981>
- Polack, F. P., Thomas, S. J., Kitchin, N., Absalon, J., Gurtman, A., Lockhart, S., Gruber, W. C. (2020). Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine. *New England Journal of Medicine*, 383(27), 2603–2615. <https://doi.org/10.1056/NEJMoa2034577>
- Qiu, J., Shen, B., Zhao, M., Wang, Z., Xie, B., & Xu, Y. (2020). A nationwide survey of psychological distress among Chinese people in the COVID-19 epidemic: implications and policy recommendations. *General Psychiatry*, 33(2), e100213. <https://doi.org/10.1136/gpsych-2020-100213>

- Reis, J. S. D. M., Silva, F. D. O., Espuny, M., Alexandre, L. G. L., Barbosa, L. C. F. M., Munhoz, A., Santos, G., Oliveira, O. J. de. (2020). The Rapid Escalation of Publications on Covid-19: A Snapshot of Trends in the Early Months to Overcome the Pandemic and to Improve Life Quality. *International Journal for Quality Research*, 14(3), 951–968. <https://doi.org/10.24874/IJQR14.03-19>
- Reis, J. S. da M., Espuny, M., Nunhes, T. V., Sampaio, N. A. de S., Isaksson, R., Campos, F. C. de, & Oliveira, O. J. de. (2021). Striding towards Sustainability: A Framework to Overcome Challenges and Explore Opportunities through Industry 4.0. *Sustainability*, 13(9), 5232. <https://doi.org/10.3390/su13095232>
- Richardson, S., Hirsch, J. S., Narasimhan, M., Crawford, J. M., McGinn, T., Davidson, K. W., ... Zanos, T. P. (2020). Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area. *JAMA*, 323(20), 2052. <https://doi.org/10.1001/jama.2020.6775>
- Rogers, J. P., Chesney, E., Oliver, D., Pollak, T. A., McGuire, P., Fusar-Poli, P., ... David, A. S. (2020). Psychiatric and neuropsychiatric presentations associated with severe coronavirus infections: a systematic review and meta-analysis with comparison to the COVID-19 pandemic. *The Lancet Psychiatry*, 7(7), 611–627. [https://doi.org/10.1016/S2215-0366\(20\)30203-0](https://doi.org/10.1016/S2215-0366(20)30203-0)
- Santos, G., Millán, A.L. (2013). Motivation and benefits of implementation and certification according ISO 9001 - the Portuguese experience. *International Journal for Quality Research* 7 (1), 71-86, ISSN: 18006450.
- Santos, G., Rebelo, M., Barros, S., Silva, R., Pereira, M., Ramos, G., Lopes, N. (2014). Developments regarding the integration of the occupational safety and health with quality and environment management systems. Book Chapter of *Occupational Safety and Health*, Nova Science publisher, 113–146, New York.
- Santos, G., Mandado, E., Silva, R., Doiro, M. (2019). Engineering learning objectives and computer assisted tools. *European Journal of Engineering Education*, 44 (4), 616-628, DOI: 10.1080/03043797.2018.1563585
- Sevinc Ozdemir, N., Belyaev, D., Castro, M. N., Balakin, S., Opitz, J., Wihadmadyatami, H., Hasirci, V. (2024). Advances in In Vitro Blood-Air Barrier Models and the Use of Nanoparticles in COVID-19 Research. *Tissue Engineering Part B: Reviews*, 30(1), 82–96. <https://doi.org/10.1089/ten.teb.2023.0117>
- Shi, S., Qin, M., Shen, B., Cai, Y., Liu, T., Yang, F., Huang, C. (2020). Association of Cardiac Injury With Mortality in Hospitalized Patients With COVID-19 in Wuhan, China. *JAMA Cardiology*, 5(7), 802. <https://doi.org/10.1001/jamacardio.2020.0950>
- Silva, S., Sá, J.C., Silva, F.J.G., Ferreira, L.P., Santos, G. (2020). Lean Green—The Importance of Integrating Environment into Lean Philosophy—A Case Study. *Lecture Notes in Networks and Systems* 122, 211–219. https://doi.org/10.1007/978-3-030-41429-0_21
- Silva, F.J. G., Kirytopoulos, K., Ferreira, L. P., Sá, J.C., Santos, G., Nogueira, M.C. C. (2022). The three pillars of sustainability and agile project management: How do they influence each other. *Corporate Social Responsibility and Environmental Management*, 29(5), 1495–1512. <https://doi.org/10.1002/csr.2287>
- Sun, Z., Doiro, M., José Carlos Sá, J.C., Santos, G. (2023). Shaping the Conscious Behaviors of Product Designers in the Early Stages of Projects: Promoting Correct Material Selection and Green Self-Identity through a New Conceptual Model. *Sustainability* 15(19), 14463, doi.org/10.3390/su151914463

- Talapatra, S., Santos, G., Gaine, A. (2022). Factors Affecting Customer Satisfaction in Eatery Business - an Empirical study from Bangladesh. *International Journal for Quality Research* 16(1),163–176. <https://doi.org/10.24874/IJQR16.01-11>
- Teixeira, P., Coelho, A., Fontoura, P., Sá, J.C., Silva, F.J.G., Santos, G., Ferreira, L.P. (2022). Combining lean and green practices to achieve a superior performance: The contribution for a sustainable development and competitiveness—An empirical study on the Portuguese context. *Corporate Social Responsibility and Environmental Management* 29(4), 887–903. <https://doi.org/10.1002/csr.2242>
- Varga, Z., Flammer, A. J., Steiger, P., Haberecker, M., Andermatt, R., Zinkernagel, A. S., Moch, H. (2020). Endothelial cell infection and endotheliitis in COVID-19. *The Lancet*, 395(10234), 1417–1418. [https://doi.org/10.1016/S0140-6736\(20\)30937-5](https://doi.org/10.1016/S0140-6736(20)30937-5)
- Vieira, T., Sá, J.C., Lopes, M.P., Santos, G., Félix, M., J., Ferreira, L.P., Silva, F.J.G., Pereira, M.T. (2019). Optimization of the cold profiling process through SMED. *Procedia Manufacturing* 38, 892–899, doi.org/10.1016/j.promfg.2020.01.171
- Vindegaard, N., & Benros, M. E. (2020). COVID-19 pandemic and mental health consequences: Systematic review of the current evidence. *Brain, Behavior, and Immunity*, 89, 531–542. <https://doi.org/10.1016/j.bbi.2020.05.048>
- Wan, Y., Shang, J., Graham, R., Baric, R. S., & Li, F. (2020). Receptor Recognition by the Novel Coronavirus from Wuhan: an Analysis Based on Decade-Long Structural Studies of SARS Coronavirus. *Journal of Virology*, 94(7). <https://doi.org/10.1128/JVI.00127-20>
- Wang, C., Pan, R., Wan, X., Tan, Y., Xu, L., Ho, C. S., & Ho, R. C. (2020a). Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. *International Journal of Environmental Research and Public Health*, 17(5), 1729. <https://doi.org/10.3390/ijerph17051729>
- Wang, W., Tang, J., & Wei, F. (2020b). Updated understanding of the outbreak of 2019 novel coronavirus (2019-nCoV) in Wuhan, China. *Journal of Medical Virology*, 92(4), 441–447. <https://doi.org/10.1002/jmv.25689>
- Williamson, E. J., Walker, A. J., Bhaskaran, K., Bacon, S., Bates, C., Morton, C. E., ... Goldacre, B. (2020). Factors associated with COVID-19-related death using OpenSAFELY. *Nature*, 584(7821), 430–436. <https://doi.org/10.1038/s41586-020-2521-4>
- Wu, F., Zhao, S., Yu, B., Chen, Y.-M., Wang, W., Song, Z.-G., ... Zhang, Y.-Z. (2020). A new coronavirus associated with human respiratory disease in China. *Nature*, 579(7798), 265–269. <https://doi.org/10.1038/s41586-020-2008-3>
- Wu, Z., & McGoogan, J. M. (2020). Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China. *JAMA*, 323(13), 1239. <https://doi.org/10.1001/jama.2020.2648>
- Xiong, J., Lipsitz, O., Nasri, F., Lui, L. M. W., Gill, H., Phan, L., ... McIntyre, R. S. (2020). Impact of COVID-19 pandemic on mental health in the general population: A systematic review. *Journal of Affective Disorders*, 277, 55–64. <https://doi.org/10.1016/j.jad.2020.08.001>
- Xu, Z., Shi, L., Wang, Y., Zhang, J., Huang, L., Zhang, C., ... Wang, F.-S. (2020). Pathological findings of COVID-19 associated with acute respiratory distress syndrome. *The Lancet Respiratory Medicine*, 8(4), 420–422. [https://doi.org/10.1016/S2213-2600\(20\)30076-X](https://doi.org/10.1016/S2213-2600(20)30076-X)
- Yülek, M.A., Santos, G. (2022). Why Income Gaps Persist: Productivity Gaps, (No-) Catch-up and Industrial Policies in Developing Countries. *Journal of Economic Issues*, 56 (1), 158-183. doi: 10.1080/00213624.2022.2020579

- Zhao, J., Liao, X., Wang, H., Wei, L., Xing, M., Liu, L., & Zhang, Z. (2020). Early Virus Clearance and Delayed Antibody Response in a Case of Coronavirus Disease 2019 (COVID-19) With a History of Coinfection With Human Immunodeficiency Virus Type 1 and Hepatitis C Virus. *Clinical Infectious Diseases*, 71(16), 2233–2235. <https://doi.org/10.1093/cid/ciaa408>
- Zhao, Q., Meng, M., Kumar, R., Wu, Y., Huang, J., Lian, N., ... Lin, S. (2020). The impact of COPD and smoking history on the severity of COVID-19: A systemic review and meta-analysis. *Journal of Medical Virology*, 92(10), 1915–1921. <https://doi.org/10.1002/jmv.25889>
- Zhou, F., Yu, T., Du, R., Fan, G., Liu, Y., Liu, Z., ... Cao, B. (2020a). Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *The Lancet*, 395(10229), 1054–1062. [https://doi.org/10.1016/S0140-6736\(20\)30566-3](https://doi.org/10.1016/S0140-6736(20)30566-3)
- Zhou, P., Yang, X.-L., Wang, X.-G., Hu, B., Zhang, L., Zhang, W., ... Shi, Z.-L. (2020b). A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature*, 579(7798), 270–273. <https://doi.org/10.1038/s41586-020-2012-7>
- Zhu, N., Zhang, D., Wang, W., Li, X., Yang, B., Song, J., ... Tan, W. (2020). A Novel Coronavirus from Patients with Pneumonia in China, 2019. *New England Journal of Medicine*, 382(8), 727–733. <https://doi.org/10.1056/NEJMoa2001017>

**José Salvador da Motta
Reis**

Centro Federal de Educação
Tecnológica Celso Suckow da
Fonseca,
Rio de Janeiro,
Brazil
jmottareis@gmail.com
ORCID 0000-0003-1953-9500

**Dayana Elizabeth
Werderits Silva**

Centro Federal de Educação
Tecnológica Celso Suckow da
Fonseca,
Rio de Janeiro,
Brazil
daywerder@gmail.com
ORCID 0000-0003-2397-4396

Gilberto Santos

ESD - Polytechnic Institute of
Cavado and Ave,
Barcelos,
Portugal
gsantos@ipca.pt
ORCID 0000-0001-9268-3272

**Luis Cesar Ferreira Motta
Barbosa**

Centro Federal de Educação
Tecnológica Celso Suckow da
Fonseca,
Rio de Janeiro,
Brazil
luiscesarfb@gmail.com
ORCID 0000-0003-4739-4556
