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RESEARCH ARTICLE

Current status of global research on novel coronavirus disease (COVID-19): a bibliometric analysis and knowledge mapping [version 1; peer review: 2 approved with reservations]

Md. Mahbub Hossain

Nature Study Society of Bangladesh, Khulna, Bangladesh

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Abstract

Background: Novel coronavirus disease (COVID-19) is a major global health concern due to its pathogenicity and widespread distribution around the world. Despite a growing interest, little is known about the current state of research on COVID-19. This bibliometric study evaluated the contemporary scientific literature to assess the evolution of knowledge on COVID-19, identify the leading research stakeholders, and analyze the conceptual areas of knowledge development in this domain.

Methods: Bibliometric data on COVID-19 related studies published until April 1, 2020, were retrieved from Web of Science core collection. Further, a quantitative evaluation and visualizations of knowledge areas in COVID-19 research were created by statistical and text-mining approaches using bibliometric tools and R software.

Results: A total of 422 citations were retained in this study, including journal articles, reviews, letters, and other publications. The mean number of authors and citations per document was 3.91 and 2.47, respectively. Also, the top ten articles, authors, and journals were identified based on the frequencies of citations and publications. Networks of contributing authors, institutions, and countries were visualized in maps, which highlight discrete developments in research collaborations. Major areas identified through evaluating keywords and text data included genetic, epidemiological, zoonotic, and other biological topics associated with COVID-19.

Conclusions: Current status of COVID-19 research shows early development in different areas of knowledge. More research should be conducted in less-explored areas, including socioeconomic determinants and impacts of COVID-19. Also, global research collaboration should be encouraged for strengthening evidence-based decision-making preventing and addressing the COVID-19 pandemic and aftermath.

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1. **Roger Chun-Man Ho** , National University of Singapore, Singapore, Singapore

2. **Siddharth Sridhar** , University of Hong Kong, Pokfulam, Hong Kong

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COVID-19, Coronavirus, Communicable diseases, Bibliometric study

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Corresponding author: Md. Mahbub Hossain (mahbub321@gmail.com)

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Introduction

Coronaviruses are RNA viruses widely found among many mammalian species, including human beings¹. Although these viruses generally have low virulence, two epidemics by severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV) are considered as major public health events in the past two decades. The case fatality rates were 10% and 37% for SARS-CoV² and MERS-CoV³, respectively. In December 2019, a novel coronavirus emerged in Wuhan City, Hubei Province of China⁴. This outbreak was unique in terms of high pathogenicity and mortality compared to the earlier epidemics by coronaviruses⁵. Soon cases affected by novel coronavirus were found outside Wuhan and eventually around the world. On January 30, 2020, the World Health Organization (WHO) declared the outbreak a public health emergency of international concern⁶. Later, the WHO named the disease a novel coronavirus as “COVID-19”, which is a short form of “coronavirus disease 2019” on February 11, 2020⁷. With a growing number of new cases and increased mortality attributable to COVID-19 pandemic⁸, global health discourses among the scientific community, policymakers, and the general population are emphasizing on what is known about this virus. Although it is known that COVID-19 is uniquely different to SARS-CoV and MERS-CoV, the scientific knowledge on COVID-19 remains limited within the scope of recently published articles. It is essential to understand the evolution of emerging scientific knowledge on COVID-19 to inform further research as well as evidence-based policymaking.

Bibliometric analysis quantitatively examines the research progress of any topic and offers a comprehensive assessment of scientific research trends, which is widely used for mapping knowledge in different scientific disciplines^{9–11}. As a research method, bibliometric study was used back in 1917 by Cole and Eales, who studied the growth of scientific production of articles published in the field of comparative anatomy¹². This approach was subsequently termed as “Bibliometrics” by eminent British scientist Allen Richard¹³. Over the years, bibliometric studies have been used for analyzing a topic or field emerging in the global knowledge landscape and evaluating the evolution of research over time^{14–16}. More importantly, it provides critical insights on most prolific authors, institutions, countries of affiliation, thematic change within the domain itself, co-citations, co-authorships, and holistic development of the field(s) of interest^{9,13,16}.

With a growing interest in COVID-19 related research across the globe, a bibliometric study may inform the current status of global research and provide meaningful insights on future research. An earlier bibliometric analysis evaluated the scientific literature on different coronaviruses¹⁷. However, there is no bibliometric analysis available to date that specifically focuses on contemporary scientific development on COVID-19. This study aimed to address this knowledge gap and conducted a bibliometric analysis to evaluate the characteristics of the current body of literature on COVID-19, identify the prolific authors, institutions, and countries involved in COVID-19 research,

and examine the evolution of key knowledge areas within COVID-19 related studies.

Methods

For this study, bibliometric data were collected from the Science Citation Index Expanded, Social Sciences Citation Index, and Emerging Sources Citation Index databases within Web of Science (WoS) core collection. These databases within WoS are maintained by Clarivate Analytics, which offer the world's leading scientific citation search and analytical information platform¹⁸. Collectively WoS collection provides enriched bibliometric data useful for citations analytics and mapping the knowledge in a given domain by examining leading authors, institutions, and collaborating nations working in a given domain of scientific research.

The following query was administered to retrieve COVID-19 related bibliometric data: “Novel coronavirus” OR “Novel coronavirus 2019” OR “2019 Novel coronavirus” OR “2019 nCoV” OR “COVID-19” OR “Wuhan coronavirus” OR “Wuhan pneumonia” OR “SARS nCoV” OR “SARS-CoV-2”. Considering the timing of the outbreak in late 2019, the search strategy was limited to 2019–2020 to retrieve data that may contain publications on COVID-19 rather than earlier coronaviruses. Also, all search fields were selected including topics, titles, and abstracts to retrieve the bibliometric data ensuring the sensitivity of the search strategy. This search was conducted in February 22, 2019 and updated in April 1, 2020, for the last time. Moreover, no restrictions on languages or publication types were applied due to the low number of publications on this recent topic. The inclusion criteria for this bibliometric study was as followings: a) journal articles published on COVID-19 topic, b) language of the publication was English, c) articles irrespective of their methodology were included, d) studies published between January 1, 2019, to April 1, 2020, were included. Furthermore, articles were excluded if they had conflicts with any of the above-mentioned inclusion criteria. The references of the retrieved articles were not evaluated, therefore, articles retrieved through citations search are the only source of data in this bibliometric study.

After extracting bibliometric data from WoS, the citations were uploaded to RefWorks (freely available alternative: Mendeley), which is a cloud-based software for citation management. Further, they were screened as per the criteria described earlier, and then finally recruited citations were uploaded to R (Version 3.6.1). Using this software, descriptive analyses were conducted to evaluate the characteristics and types of documents. Also, the WoS metrics were used to assess the top ten impactful articles in the literature in terms of citations, the top 10 authors and journals based on the number of published documents on COVID-19. In addition, co-authorship among all the authors in the bibliography was assessed, and an evaluation of how many of them were connected within documents authored or co-authored by individuals was conducted.

Further, the affiliating institutions and countries of the respective authors were mapped using a network analysis approach.

This set of analyses allowed to evaluate the nature and magnitude of collaboration at the individual, institutional, and international levels and how such collaborated impacted the knowledge base on COVID-19. Also, keywords and texts in titles and abstracts within scientific documents were identified and evaluated using text-mining approaches using *shiny* package in R (Version 3.6.1). At this stage, network analyses were conducted to assess the connectedness among those documents and related keywords. Furthermore, the cooccurrence of multiple authors, keywords, institutions, and countries, different thresholds were used to create visualizations of frequency distributions for each variable, whereas all entries within each variable were assessed for the same threshold to ensure equitable comparisons within respective fields of analyses. Furthermore, the relational mapping among the authors, institutions, countries, and common keywords were created using *VOSviewer* software, which is a bibliometric tool for visualization of citations data. In this mapping process, networks were developed at different thresholds for authors ($n = 3$ documents per author), institutions ($n = 7$ documents per institutions), countries ($n = 1$ document per country), and keywords ($n = 3$ cooccurring keywords). In addition, a multi-dimensional scaling approach was used to conduct a factorial analysis of 50 most-occurring research terms in the bibliometric data in R package as stated earlier. This allowed constructing a conceptual structure map depicting hierarchical relationships among knowledge areas within the research landscape of COVID-19.

Results

Summary of bibliometric data and the current status of scientific production on COVID-19

A total of 422 bibliometric records were recruited in this study, which were authored by 1652 authors with 3.91 authors per document (Table 1). Most documents ($n = 1581$) had multiple authors, and the mean citations received per document was 2.47. A major proportion of the publications were articles (33.41%) and editorials (32.23%).

In addition, top ten articles based on the number of citations in WoS were identified (Table 2), which included genetic, epidemiological, and clinical studies on COVID-19. Among the authors, Mahase E. has the highest number of publications ($n = 13$) followed by Akhmetzhanov AR., Linton NM., Nishiura H., and Zhang W. with seven publications per author. Also, top ten journals were identified that published the highest number of documents, which include British Medical Journal ($n = 47$) followed by The Lancet ($n = 37$), Eurosurveillance ($n = 22$), Journal of Medical Virology ($n = 22$), and Intensive Care Medicine ($n = 13$).

Networks of authors, institutions, and nations in COVID-19 research

A network map of co-authors who contributed to COVID-19 research was created at the threshold of 3 documents per author, which found 52 collaborating authors, as illustrated in Figure 1. Scattered zones show groups of collaborating authors, whereas connections between individuals and groups are plotted

Table 1. Overview of published scientific documents on COVID-19.

Description	Findings
Summary of the bibliometric items	
Total documents	422
Author's Keywords	371
Average citations per documents	2.47
Total authors	1652
Authors of single-authored documents	71
Authors of multi-authored documents	1581
Documents per Author	0.26
Authors per Document	3.91
Co-Authors per Documents	5.55
Collaboration Index	5.08
Document types	
Articles	141 (33.41%)
Editorials	136 (32.23%)
Letters or correspondence	67 (15.88%)
Reviews	24 (5.69%)
Other forms of publications (news, corrections, reprints etc.)	54 (12.8%)

accordingly. Figure 2 shows the network of collaborating institutions that were affiliated with at least seven documents on COVID-19 research. This threshold identified 16 collaborating institutions, including Capital Medical University (number of documents, $n_d = 13$; number of citations, $n_c = 237$), Huazhong University of Science and Technology ($n_d = 18$, $n_c = 167$), and Wuhan University ($n_d = 15$, $n_c = 154$).

Further, the bibliometric records were analyzed for the contributing countries and a network was developed using co-authorship among scholars from those nations. Any collaborating country with at least one publication was included in this map (Figure 3). Among global nations, China has the highest number of documents ($n = 185$), followed by the US ($n = 68$), UK ($n = 36$), Italy ($n = 23$) and Canada ($n = 23$).

Intellectual evolution among documents in the key knowledge areas

In this study, a visualization guided by quantitative evaluation of the cooccurrence of keywords was prepared, as depicted in Figure 4. A threshold of at least three cooccurrence of a keyword was set to identify the most frequent research terms indexed in the literature, which revealed a total of 69 keywords. The top ten cooccurring words were “coronavirus” ($n = 69$), “sars” ($n = 47$), “2019-ncov” ($n = 43$), “covid-19” ($n = 44$), “sars-cov-2” ($n = 26$), “pneumonia” ($n = 25$), “wuhan” ($n = 18$), and “outbreak” ($n = 18$).

Table 2. Top ten articles, authors, and journals related to COVID-19 publications.

Top ten articles on COVID-19 based on citations			
Serial No.	Title	First author and source	Frequency of citations
1	Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China	Huang, C.; The Lancet	124
2	A Novel Coronavirus from Patients with Pneumonia in China, 2019	Zhu, N.; New England Journal of Medicine	86
3	A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster	Chan, J.F.; The Lancet	71
4	A pneumonia outbreak associated with a new coronavirus of probable bat origin	Zhou, P.; Nature	59
5	Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study	Chen, N.; The Lancet	54
6	Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding	Lu, R.; The Lancet	36
7	Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study	Wu, J.T.; The Lancet	28
8	A novel coronavirus outbreak of global health concern	Wang, C.; The Lancet	25
9	Transmission of 2019-nCoV Infection from an Asymptomatic Contact in Germany	Rothe, C.; New England Journal of Medicine	24
10	The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health - The latest 2019 novel coronavirus outbreak in Wuhan, China	Hui, D.S.; International Journal of Infectious Diseases	24
Top ten authors based on number of published documents on COVID-19			
Serial No.	Name of the author	Frequency of publications	Percentage (%)
1	Mahase, E.	13	3.08
2	Akhmetzhanov, AR.	7	1.66
3	Linton, NM.	7	1.66
4	Nishiura, H.	7	1.66
5	Zhang, W.	7	1.66
6	Chen, J.	6	1.42
7	Drosten, C.	6	1.42
8	Hayashi, K.	6	1.42
9	Kinoshita, R.	6	1.42
10	Kobayashi, T.	6	1.42

Top ten journals based on scientific publications on COVID-19			
Serial No.	Name of the journal	Frequency of publications and percentage (%)	Impact Factor as per Journal Citations Report 2018
1	British Medical Journal	49 (11.61)	27.604
2	The Lancet	37 (8.77)	59.1
3	Eurosurveillance	22 (5.21)	7.42
4	Journal of Medical Virology	22 (5.21)	2.05
5	Intensive Care Medicine	13 (3.08)	18.97
6	Journal of Clinical Medicine	13 (3.08)	5.69
7	Emerging Microbes & Infections	9 (2.13)	6.21
8	Journal of Korean Medical Science	9 (2.13)	1.72
9	Radiology	9 (2.13)	7.6
10	Nature Medicine	7 (1.66)	30.64
10	New England Journal of Medicine	7 (1.66)	70.67

Figure 1. Network of authors contributing to the COVID-19 research.

Figure 2. Network of institutions affiliated to the COVID-19 research.

A factorial analysis was conducted among the leading 50 key terms in the bibliometric data using a multi-dimensional scaling approach (Figure 5). This analysis resulted in a dendrogram of repeatedly co-appearing keywords in hierarchical clustering, which highlights conceptual structures in the research field. The first cluster in this dendrogram (in blue) included research terms including diversity, multiple sequence alignment, and

sars-like coronaviruses. Another cluster (in red) comprised of research terms related to pathogenicity of coronavirus outbreak, earlier outbreaks with other typologies, epidemiology, and diagnostic approaches. Both structures shared several common thematic areas, including zoonotic connections in COVID-19 epidemiology and genetic and molecular properties of interest in COVID-19 research.

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Figure 5. Conceptual structure map of COVID-19 research using multidimensional scaling.

Discussion

This bibliometric study and knowledge mapping identified contemporary scientific documents on COVID-19 from scholarly sources. The findings of this study reflect the recent scholarly growth of the global body of knowledge on COVID-19. Most documents had multiple authors from different collaborating institutions and nations, which highlight the productivity of scientific activities. Moreover, research keywords presented in the bibliometric data reflect the complexity and inclusion of multiple disciplines like virology, microbiology, infectious diseases, clinical medicine, public health, allied health sciences, social sciences, and other branches of knowledge. Such scholarly growth of the knowledge base may help in understanding the ontology and phenomenology of a new global health challenge imposed by COVID-19.

Notably, the affiliating institutions and nations collaborated in COVID-19 research may inform the utility of global research collaboration, particularly during complex public health problems where multiple stakeholders from different institutions and contexts may offer diverse resources and competencies in addressing knowledge gaps in a more efficient manner compared to individualistic approaches. This can be profoundly challenging for low- and middle-income countries, like nations in Africa and South Asia, who have suboptimal research capacities and poor evidence-base to make informed decisions on highly prevalent health problems¹⁹.

Another challenge is a critical lack of technological infrastructure in such contexts, which reinforces the need to strengthen global collaborations for research and evidence synthesis. For example, resource-constrained contexts have lesser availability and accessibility to advanced technologies, which may limit their abilities to conduct research requiring tools like deep learning or other computational approaches^{20,21}. Also, this may restrict opportunities for substituting time-intensive lab-based research through simulation or increase the speed and quality of research processes. This may be a reason for the lack of representation of studies from countries in South Asia, South America, and Africa. Future efforts should focus on strengthening research capacities in those contexts is essential to improve regional and global knowledge on persisting and emerging diseases affecting global populations.

Also, it is essential to acknowledge the need for global collaborations as the magnitude of the problem necessitates a series of large-scale analyses, exchange of perspectives, knowledge synthesis, and translating the same to inform evidence-based policies and practices^{22,23}. More importantly, increased collaborations in research are likely to facilitate trust and cooperation in developing scalable solutions globally, minimizing the cost and maximizing human benefits beyond borders^{24,25}. Lessons learned from research collaboration can foster hope in existing global health disparities, particularly in developing vaccines and other preventive solutions^{26,27}. These aspects are critical for the

overall development of COVID-19 related research and practice as the current evidence on collaboration shows scattered growth of research groups, which may affect the true potential that collaborative efforts may offer in this scenario.

This study identified top keywords that appeared in scientific literature and demonstrated how they co-appeared across studies taking intellectual roots from earlier studies. Moreover, an evolution of conceptual structure using those keywords inform the current scenario of uncontrolled observations retrieved from global studies. Keywords are useful not only to retrieve studies from databases or topics within studies, but they also tell the scientometric themes underlying the information presented in a document^{28,29}. In addition, these conceptual constructs may inform future scientific measures to define and distinguish how sub-domains within the knowledge base on COVID-19. Furthermore, similar keywords appeared in multiple documents in this study, among which a one-third were original articles, which informs the early stage of research. This early finding may offer critical directions of scientific development in this knowledge domain. Also, this study found more frequent appearances of epidemiological, genetic, and molecular biological keywords in COVID-19 studies, whereas some keywords indicated an emergence of zoonotic topics, including other animals related to the human food chain or ecology.

It is notable that the cooccurrence of keywords analysis or conceptual structure mapping did not find significant presence of social, economic, political, or cultural determinants of COVID-19 in the global landscape. It is increasingly being recognized that neither disease nor health can happen in isolation from the complex web of those determinants of human lives^{30–33}. The findings of this study highlight this gap, which necessitates further multi-sectoral research on how different determinants can be associated with higher or lower risks of COVID-19 among individuals or populations. In addition, programs and policies for addressing epidemic outbreaks may influence physical and psychosocial health outcomes in diverse population groups^{34,35}, which remains another potential area for future research. Moreover, there is a lack of research that may inform the preventive measures like vaccinations, pharmacological interventions, clinical prognosis, and outcomes of COVID-19. Maybe such studies yet to be available in the future, which will enrich future scientometric analyses and evidence mapping processes.

Another issue is the existing literature mentions little about the psychosocial and economic consequences of COVID-19. A major public health crisis like COVID-19 can affect those aspects of lives and create lasting problems among the affected populations^{36,37}. Perhaps it is too early to estimate such impacts or get them published in indexed sources, which would need more research and timely communication across journals and other media. In addition to epidemiological and genetic studies, psychological, econometric, and social sciences research assessing those concurrent and future challenges should be prioritized to improve the knowledge base in those areas.

Limitations of this study

This study has several limitations that must be acknowledged to apprehend the findings and address those limitations through

future research. First, this study used three databases from WoS core collection, which may have included most studies in a given domain, whereas it may exclude studies that are exclusively indexed in other databases. This may affect the generalizability of the findings. Second, newly published studies may take some time to get indexed in WoS, which could be sourced from searching individual journals that published articles related to COVID-19. A similar gap exists in terms of preprints that are available in respective servers, and insights from those articles cannot be reflected in this study. Also, research studies may take time to get published as journal articles and to be indexed in associated databases, which may also limit the scope of current literature to reflect contemporary knowledge. Third, a bibliometric analysis provides an overview of the evolution of a knowledge domain that is methodologically different than approaches used in clinical reviews. Such reviews may have different objectives and methods of synthesis, which were beyond the scope of this study. However, this study evaluated the knowledge evolution on COVID-19, which may have long-term impacts on the field of COVID-19 studies and future discourses on public health emergencies. The above-mentioned issues should be considered to use the findings of this study and conduct future research and evidence synthesis on COVID-19 addressing those challenges.

Conclusions

A public health emergency, like the COVID-19 pandemic, may affect different frontiers of human lives globally. To solve such problems, it is necessary to fully understand the problem and solutions that may address this. This need for knowledge is a fundamental force that keeps science alive and allows scientists to thrive in their research domains bringing the best possible methods and materials to answer real-life questions. Solving a complex public health problem like COVID-19 needs robust knowledge generated through rigorous methods specific to each problem related to different dimensions of COVID-19 as well as the lives of millions of people around the world. This study provided a global bibliometric evaluation of COVID-19 related studies, which may facilitate ongoing and future research. Such academic and professional efforts in understanding COVID-19 and addressing the same will be informed by the knowledge base we have today, which will continue to evolve over time, enriching science and societies globally.

Data availability

Underlying data

Open Science Framework: Bibliometric Analysis of COVID-19 Research, <https://doi.org/10.17605/OSF.IO/SJB86>³⁸. Registered on 11th May 2020, <https://osf.io/65v2z>

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Siddharth Sridhar

Department of Microbiology, University of Hong Kong, Pokfulam, Hong Kong

The authors perform bibliometric analysis of the COVID-19 literature at a relatively early stage of the pandemic. There are some interesting observations, but I have the following reservations:

1. Basically, most research is expected to originate from areas where the case load is highest. Most of the bibliometric analysis was performed at a relatively early stage of the pandemic at which time the bulk of COVID-19 case load was in China. Africa, for example, had negligible case loads in February/ March 2020. In fact, COVID-19 spread to high-income countries in Europe first. This would explain why the majority of research was conducted in China and Europe rather than other regions. The author's point about less research from low-income countries is valid in general, but I would like to point out that this disparity is probably not well illustrated by this study. Such a conclusion can only be reached from bibliometric analysis of several year's data, which is not possible at this stage.
2. A large volume of early work on COVID-19 was published in Chinese. Not including works in other languages has probably skewed the data. Also many many pre-prints, which are still not published due to heavy backlog of journals.
3. Not sure what the value of including individual researcher's names is.
4. The other author has pointed out another publication on a similar topic. Please address additional value provided by this study.

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Emerging infectious diseases

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 17 July 2020

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Roger Chun-Man Ho

Department of Psychological Medicine, National University of Singapore, Singapore, Singapore

I have the following comments and need to review them again.

- Can the authors discuss a recent COVID-19 review on this topic? What is the value-added by this new review by contrasting with an existing review?

Tran BX, Ha GH, Nguyen LH, et al. Studies of Novel Coronavirus Disease 19 (COVID-19) Pandemic: A Global Analysis of Literature. *Int J Environ Res Public Health*. 2020;17(11):4095. Published 2020 Jun 8. doi:10.3390/ijerph17114095¹.

- In Figure 4, can the authors explain why mental health or negative mental health consequences associated with COVID-19 was not found to be there in the Figure?

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Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: COVID-19 research

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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