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Review

Global trends and research patterns in medical surge capacity and response during the Covid-19 pandemic: A bibliometric analysis

Heshan Radeesha de Silva[1], Nurgul Ablakimova[2], Svetlana Rachina[1], Daria Strelkova[1], Sergey Avdeev[1], Nikolay Pimenov[1], Anna Vlasenko[3]

[1]Department of Hospital Therapy, I. M. Sechenov First Moscow State Medical University, Moscow, Russia; [2]Department of Pharmacology, West Kazakhstan Marat Ospanov Medical University, Aktobe, Kazakhstan; [3]Centre of Evidence-based medicine and biostatistics, Samara State Medical University, Samara, Russia

Abstract. *Background and Aim:* This study aims to analyze global trends and research patterns related to medical surge capacity and response during the Coronavirus Disease 2019 (COVID-19) pandemic through a bibliometric analysis. *Methods:* The analysis was conducted using data from the Scopus database, focusing on original papers published between 2020 and 2024. Key metrics, including publication trends, geographical distribution, institutional affiliations, and citation statistics, were evaluated. The search was limited to English-language papers. *Results:* A total of 523 articles were deemed relevant for the analysis. A significant increase in research output was observed during the early stages of the pandemic, with the United States, Canada, and the United Kingdom leading in the number of publications. Major contributors included key institutions such as the University of Toronto, and the Icahn School of Medicine, which represent strong public health research groups. Two Italian authors from the same university, Ragazzoni L. and Della Corte F., were the most prolific in terms of both the number of articles published and citations received. The analysis highlighted the international scope of the research and the willingness of different research groups to collaborate. A shift in research focus was also noted, with keywords moving from immediate pandemic response efforts (human resources, surge capacity) to more specialized topics (machine learning and the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) vaccine). *Conclusions:* This study provides a comprehensive overview of the global research landscape on medical surge capacity during the COVID-19 pandemic. The findings highlight the critical role of robust public health systems and international collaboration in responding to global health crises. (www.actabiomedica.it)

Key words: bibliometric analysis, COVID-19 pandemic, medical surge capacity, public health, surge response

Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic, caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus, has been one of the most significant global health crises in modern history. Since its emergence in late 2019, the virus has rapidly spread worldwide, overwhelming healthcare systems and prompting unprecedented public health measures. The sudden rise in COVID-19 cases created an urgent need to enhance medical surge capacity (1). Medical surge capacity describes a healthcare system's capability to assess and manage a sudden, overwhelming influx of patients that surpasses its standard operational limits (2). This exposed critical gaps in healthcare infrastructure, including shortages

of medical supplies, insufficient hospital beds, and the lack of scalable solutions to manage the influx of patients. Medical surge capacity is a cornerstone of effective pandemic response, encompassing strategies to handle increased patient load, such as converting non-traditional spaces into care units, reallocating healthcare resources, and optimizing workforce management (3). The pandemic has underscored the importance of resilient healthcare systems capable of adapting swiftly to crises. As a result, there has been a surge in research focused on understanding and improving medical surge capacity and response strategies during the COVID-19 pandemic (4). Surge capacity is emphasized as a pillar for emergency preparedness in building resilient healthcare facilities according to WHO's Health Emergency and Disaster Risk Management (Heath-EDRM) framework (5). Global Preparedness Monitoring Board's annual report on Global Preparedness for health emergencies issued on September 2019 warned that a rapidly spreading pandemic due to a respiratory pathogen requires adequate investment in surge capacity and urged to develop a system to immediately share sequences of any new pathogen for public health purposes, which exposed public health policy failures just prior to the COVID-19 pandemic (6). In 2020 surge capacity for critical care increased to an 8% in Organization for Economic Co-operation and Development (OECD) countries (7). Prior to the COVID-19 outbreak, high income OECD countries such as Greece, Malta, Ireland, New Zealand and Japan had the lowest Intensive Care Unit (ICU) bed capacity which was around 4 to 5 ICU beds per 100,000; Greece was able to double their ICU bed capacity during the first wave and by 2021, Malta was able to increase it to around 100 beds from initially having 20 beds (8–12). This bibliometric analysis aims to map the global research landscape on medical surge capacity and response in the context of the COVID-19 pandemic. Although the body of literature on this topic has grown substantially, there remains a need to synthesize and analyze these studies to identify emerging research trends, key themes, and gaps in the existing knowledge. By examining research outputs from 2020 onward, this study seeks to provide a comprehensive overview of the scholarly efforts addressing the challenges posed by the pandemic.

Materials and Methods

This analysis addresses several key questions: What are the dominant themes in research on medical surge capacity during the COVID-19 pandemic? Which countries and institutions have been at the forefront of this research? Who are the leading contributors, and what are the most influential publications? Understanding these factors will not only highlight the progress made in this field but also help guide future research to better prepare for potential healthcare crises.

Data source and search strategy

A comprehensive literature search was conducted using the Scopus database to identify publications related to medical surge capacity and response during the COVID-19 pandemic. Scopus was selected as the primary database due to its broad, interdisciplinary coverage of peer-reviewed research and citation data (13). Additionally, since Biblioshiny is optimized for working with a single database source, Scopus provided the most suitable and consistent dataset for bibliometric analysis. The search query was designed to capture relevant studies published from 2020 onward, focusing on the intersection of the COVID-19 pandemic and healthcare system surge capacity.

The specific search string used was:

TITLE-ABS-KEY((“SARS-CoV-2” OR “COVID-19” OR “NOVEL CORONAVIRUS” OR “CORONAVIRUS DISEASE 2019” OR “2019-nCoV” OR “COVID” OR “SARS2” OR “2019-NCOV”) AND (“MEDICAL SURGE RISK” OR “MEDICAL SURGE RESPONSE” OR “MEDICAL SURGE” OR “PATIENT INFLUX” OR “HOSPITAL SURGE” OR “HEALTHCARE SURGE” OR “SURGE CAPACITY” OR “SURGE RESPONSE” OR “EMERGENCY INFLUX” OR “MEDICAL INFLUX” OR “SURGE MANAGEMENT” OR “SURGE IN DEMAND” OR “SURGE IN PATIENT VOLUME”))AND PUBYEAR > 2019 AND (LIMIT-TO (SUBJAREA,”MEDI”)) AND (EXCLUDE (DOCTYPE,”re”) OR EXCLUDE (DOCTYPE,”ch”)OREXCLUDE(DOCTYPE,”cp”)

OR EXCLUDE (DOCTYPE,"bk")) AND (LIMIT-TO (LANGUAGE,"English"))

This search query was executed in August 2024, yielding a final result of 567 documents.

Inclusion and exclusion criteria

The search was restricted to articles published in English and within the subject area of "Medicine" to ensure relevance to healthcare and medical surge capacity. English, as the dominant language of scientific communication, was chosen to ensure broad accessibility, facilitate reproducibility, and enhance the comparability of findings across international research. The search was restricted to the "Medicine" subject area to maintain focus on clinical and operational aspects of surge capacity, though we acknowledge that multidisciplinary perspectives (e.g., health policy, Artificial Intelligence) could offer additional insights. Document types such as literature reviews, books, book chapters, and conference papers were excluded, with the focus primarily on original research articles. Prisma flow diagram further illustrates the screening strategy (Figure 1).

The 567 articles identified through the Scopus search were further screened for relevance to the research topic. A total of 44 articles were excluded because they did not align with the specific focus on medical surge capacity and response during the COVID-19 pandemic. These articles were removed after a thorough review of their titles, abstracts, and, when necessary, full texts by two experts (S. R. and D. S.). Subsequently, all authors discussed to resolve any disagreement and finalize the analysis. The final dataset consisted of 523 articles, which were deemed relevant for the bibliometric analysis.

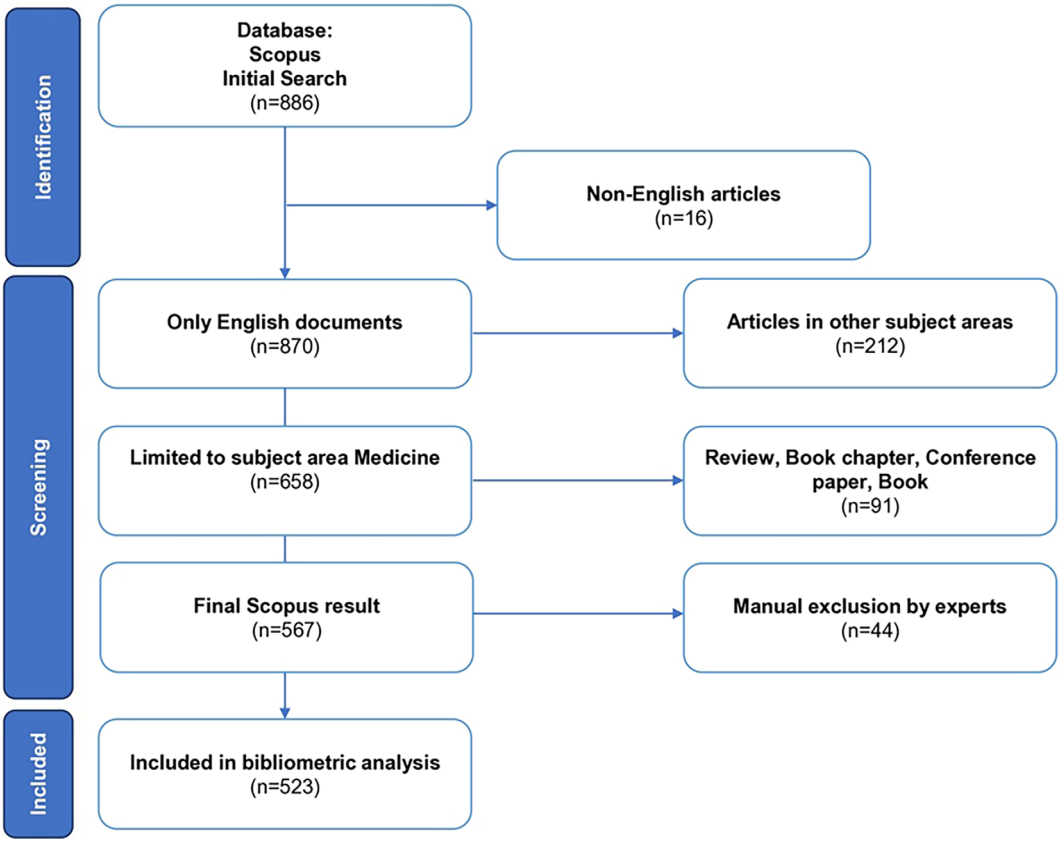

Figure 1. Prisma flow diagram of screening.

Data analysis

The bibliometric analysis was conducted using the Bibliometrix R-package and its associated web-based interface, Biblioshiny. The Bibliometrix package was chosen for its comprehensive tools for conducting and visualizing bibliometric analyses, including the ability to evaluate research trends, co-authorship networks, and keyword co-occurrences (13–15). The following analyses were performed:

- Descriptive Analysis: A basic descriptive analysis was conducted to summarize annual scientific output, the most productive authors, institutions, and countries, as well as the most frequently cited articles.
- Network Analysis: Co-authorship networks were mapped to identify collaboration patterns among authors, institutions, and countries. This analysis helped uncover the key contributors to research on medical surge capacity during the COVID-19 pandemic.
- Thematic Analysis: A keyword co-occurrence analysis was performed to identify the main themes and topics within the dataset. The evolution of these themes over time was also examined to understand how the research focus shifted throughout the pandemic.
- Citation Analysis: Citation metrics were analyzed to determine the most influential articles and authors in the field. This included identifying highly cited papers that have had a significant impact on the development of the field.

All analyses were performed using RStudio (version 4.4.1) with the Bibliometrix package (version 4.3.0) and the Biblioshiny interface (version 4.1).

Data visualization

The results of the bibliometric analysis were visualized using a combination of Biblioshiny's built-in tools, RStudio, RAW graphs, and Flourish studio. Visualization techniques included bar charts, network diagrams, thematic maps, and trend plots, which provided a comprehensive overview of the research landscape.

Results

Annual scientific production

The annual scientific production on medical surge capacity and response during the COVID-19 pandemic demonstrated a clear trend over the years, reflecting the evolving focus of the research community (Figure 2). The highest level of activity was observed in 2020, with 160 articles published. This peak corresponds to the initial outbreak of the

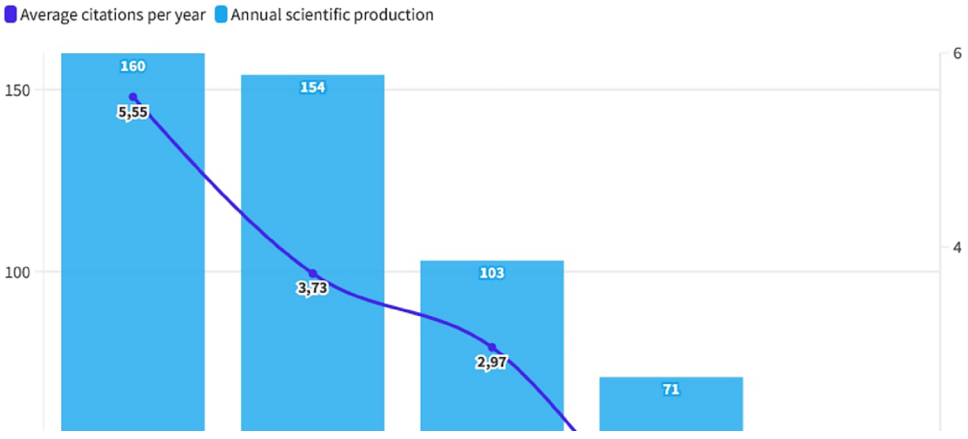

Figure 2. Average citations per year and annual scientific production on medical surge capacity and response to the COVID-19 pandemic.

COVID-19 pandemic, when the urgent need for research on medical surge capacity was most critical. There was a slight decrease in publications in 2021, with 154 articles. This sustained level of production indicates continued interest and research efforts as the pandemic evolved, and new challenges emerged. A significant decline occurred in 2022, with only 103 articles published. This reduction suggests that the research focus may have begun to shift towards more specialized or long-term aspects of pandemic response or that initial surges in research had addressed many immediate questions. By 2024, the number of publications further decreased to just 28 articles.

This substantial drop reflects a potential stabilization in the field, indicating that the urgency for research had diminished, or that research efforts had shifted towards other emerging global health challenges. This trend in annual scientific production illustrates the rapid mobilization of research efforts in response to the pandemic, followed by a gradual decline as the immediate crisis abated and the research landscape evolved.

The most productive authors, institutions, and countries

The analysis of the most productive authors identified three key contributors. Ragazzoni L. emerged as the most prolific author, with 6 articles published. In terms of citations, he had a significant impact in 2020, with citation counts of 9, 37, 43, and 23 for different articles. Della Corte F. ranked second in productivity, having authored 5 articles. Like Ragazzoni, this author also garnered substantial citations in 2020, with the citation counts of 9, 37, 43, and 23 for various publications. Backer H., from the California Emergency Services Authority in the USA, published 4 papers and was another notable contributor. His citation impact primarily occurred in 2023, with citation counts of 4 and 13 for two different papers (Figure 3).

These authors represent the leading voices in research on medical surge capacity during the COVID-19 pandemic. Ragazzoni L. and Della Corte F., from the same scientific group at Università del Piemonte Orientale in Italy, made significant contributions early in the pandemic, while Backer H.'s work gained recognition slightly later. The citation patterns

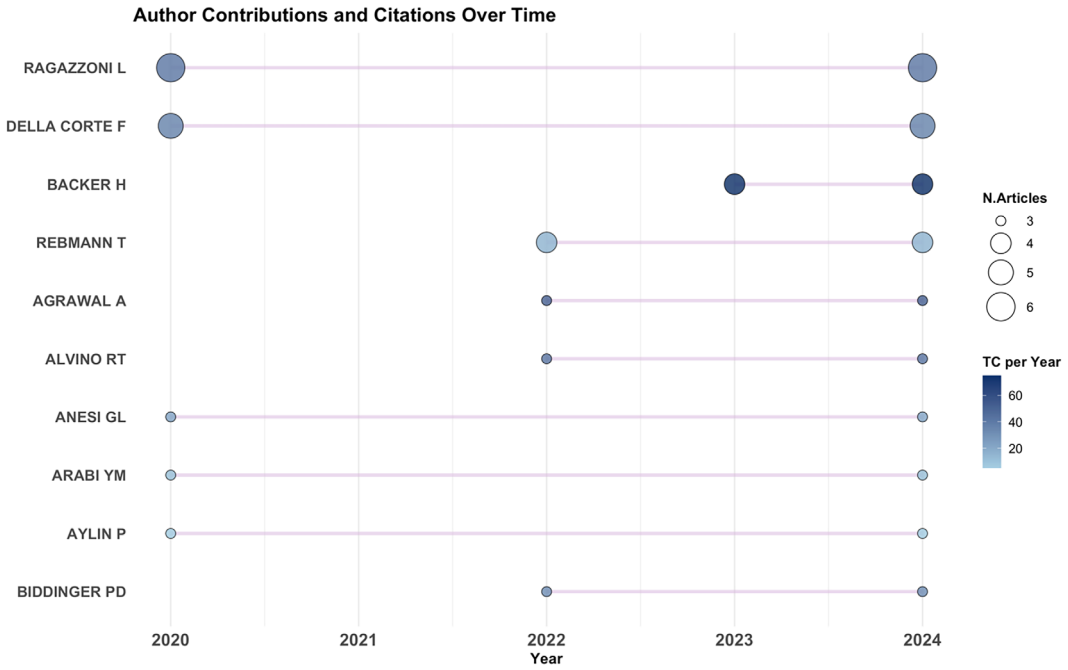

Figure 3. Top 10 most productive authors on medical surge capacity and response to the COVID-19 pandemic.

suggest that while initial research efforts received substantial attention, the focus of citations shifted over time, possibly reflecting changes in research priorities or the evolving nature of the pandemic response. The analysis of institutional productivity is presented in Table 1. The University of Toronto leads the list with a total of 33 articles, demonstrating consistent growth in its research output from 2020 to 2024. This steady increase highlights the university's sustained commitment to research in this critical area throughout the pandemic. The Icahn School of Medicine in the USA, was another major contributor, publishing 11 articles in 2020, which more than doubled to 24 articles by 2021. Its output slightly increased, eventually reaching 27 articles by 2024. This pattern reflects the institution's strong and ongoing research efforts during the pandemic. Harvard Medical School's research output also showed a steady rise, starting with 5 articles in 2020 and increasing to 10, 14 and 15 articles in 2021, 2022, and 2023, respectively, before reaching 18 articles in 2024. This gradual increase in publications reflects Harvard's growing involvement in research on medical surge capacity over the course of the pandemic.

These institutions have played a pivotal role in advancing the understanding and management of medical surge capacity during the COVID-19 pandemic, with the University of Toronto leading in total output. The consistent growth in publications from these institutions highlights their significant contributions to global research efforts during this challenging period. The analysis of the most productive countries highlighted significant contributions from the USA, UK, Canada, Italy, and Australia (Figure 4). In particular, authors from the USA demonstrated a rapid and sustained increase in scientific output. By 2020, 258 authors from the USA had published on the topic, which more than doubled to 539 by 2021. The upward trend continued with 687 authors in 2022, 805 authors in 2023, and reaching 871 authors by 2024. The UK also made substantial contributions to the field, with a total of 234 authors. The UK's research output began with 50 authors in 2020 and experienced significant and steady growth each year, culminating in 234 authors by 2024. This steady growth reflects the UK's active involvement in pandemic-related research. Canada had a total of 190 authors, marking it as a key and consistent contributor to global research efforts.

Table 1. Top 6 most productive institutions on medical surge capacity and response to the COVID-19 pandemic

Affiliation	Year	Total Number of Articles by the end of each Year	Total Number of Articles
UNIVERSITY OF TORONTO	2020	16	33
	2021	29	
	2022	30	
	2023	32	
	2024	33	
ICAHN SCHOOL OF MEDICINE AT MOUNT SINAI	2020	11	27
	2021	24	
	2022	26	
	2023	26	
	2024	27	
HARVARD MEDICAL SCHOOL	2020	5	18
	2021	10	
	2022	14	
	2023	15	
	2024	18	
ERASMUS UNIVERSITY MEDICAL CENTER	2020	0	17
	2021	8	
	2022	17	
	2023	17	
	2024	17	
ALBERT EINSTEIN COLLEGE OF MEDICINE	2020	3	14
	2021	14	
	2022	14	
	2023	14	
	2024	14	
UNIVERSITY OF CALIFORNIA	2020	4	14
	2021	5	
	2022	12	
	2023	13	
	2024	14	

The most cited articles

The top 10 most cited articles identified through bibliometric analysis in the field of medical surge capacity and response during the COVID-19 pandemic are presented in Table 2. The first three articles received

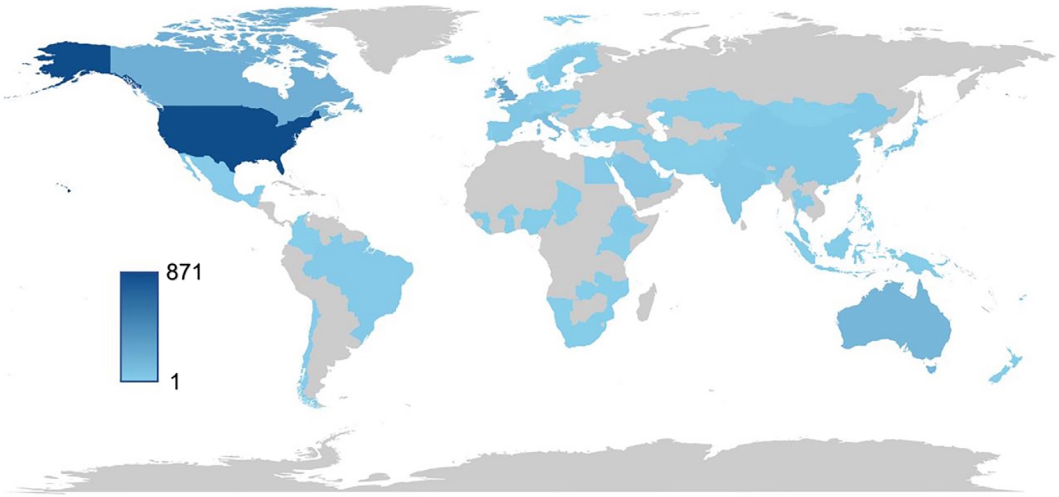

Figure 4. Most productive countries on medical surge capacity and response to the COVID-19 pandemic, represents the number of authors who published on this topic.

348, 299 and 272 citations, respectively. Kandel et al., affiliated with the World Health Organization (WHO) Health Emergency Program in Geneva, Switzerland, evaluated how different countries vary in their capacity to prevent, detect, and respond to outbreaks (16). Iuliano et al., compared how the disease severity and healthcare utilization changed during the early Omicron variant compared to previously reported high transmission periods of SARS-CoV-2 in the USA, from the end of 2020 to the beginning of 2022 (17). Iuliano A.D. was part of the CDC COVID-19 Emergency Response Team, while the co-authors were affiliated with Johns Hopkins University, Booz Allen Hamilton, and Becton Dickinson in the USA (17). Aziz et al., highlighted the challenges of managing patients during ICU surges (18). While Aziz S. was affiliated with the NHS in the UK, most of the other authors were associated with different institutions in the UK, USA, Italy, and Canada (18).

Author collaboration

According to the author collaboration network analysis (Figure 5), Ragazzoni L. and Backer H. primarily collaborated with 3 authors each, and these scientific groups did not collaborate with one another. Agrawal A., one of the top 10 most productive authors, has the largest collaboration network. The global collaboration chord diagram (Figure 6) illustrates the international nature of research in this domain. Leading countries in this field include the UK, USA, Italy, and Canada. These collaborations reflect a global response and shared expertise in addressing the challenges of medical surge capacity during the pandemic.

Topics in research

The tree map of keywords (Figure 7) revealed that the primary areas of focus within the research were "human", "surge capacity", and "pandemic", which were mentioned 474, 469, and 445 times, respectively, each accounting for 7% of the total keywords. The trend topics diagram (Figure 8) illustrated the evolution of research themes over time. Between 2022 and 2024, the focus shifted towards advanced topics, including machine learning, SARS-CoV-2 vaccines, and military personnel. These topics gained prominence as the pandemic response evolved. In contrast, earlier research (from 2020 to 2022) concentrated on foundational themes. These findings indicate a progression in research focus, moving from immediate pandemic response efforts to more specialized and technical aspects of crisis management.

Table 2. Top 10 most cited articles on medical surge capacity and response to COVID-19 pandemic

Rank	Study ID	Title	DOI	Total citations
1	Kandel N, et al (16)	Health security capacities in the context of COVID-19 outbreak: an analysis of International Health Regulations annual report data from 182 countries	10.1016/S0140-6736(20)30553-5	348
2	Iuliano AD, et al (17)	Trends in Disease Severity and Health Care Utilization During the Early Omicron Variant Period Compared with Previous SARS-CoV-2 High Transmission Periods — United States, December 2020–January 2022	10.15585/mmwr.mm7104e4	299
3	Aziz S, et al (18)	Managing ICU surge during the COVID-19 crisis: rapid guidelines	10.1007/s00134-020-06092-5	272
4	Arabi YM, et al (19)	COVID-19: a novel coronavirus and a novel challenge for critical care	10.1007/s00134-020-05955-1	212
5	Glasbey J, et al (20)	Effect of COVID-19 pandemic lockdowns on planned cancer surgery for 15 tumour types in 61 countries: an international, prospective, cohort study	10.1016/S1470-2045(21)00493-9	195
6	Weissman GE, et al (21)	Locally informed simulation to predict hospital capacity needs during the covid-19 pandemic	10.7326/M20-1260	176
7	Verelst F, et al (22)	Indications for healthcare surge capacity in European countries facing an exponential increase in coronavirus disease (COVID-19) cases, March 2020	10.2807/1560-7917 ES.2020.25.13. 2000323	139
8	McCabe R, et al (23)	Adapting hospital capacity to meet changing demands during the COVID-19 pandemic	10.1186/s12916-020-01781-w	130
9	Cheng FY, et al (24)	Using machine learning to predict ICU transfer in hospitalized COVID-19 patients	10.3390/jcm906166810.1186/ s13613-022-01011-x	129
10	Kadri SS, et al (25)	Association between caseload surge and covid-19 survival in 558 u.s. hospitals, march to august 2020	10.7326/M21-1213	128

Discussion

This bibliometric analysis provides an extensive overview of global trends and research patterns in medical surge capacity and response during the COVID-19 pandemic. The study found a significant increase in publications related to medical surge capacity in the early years of the pandemic, with a concentration of research reported mainly from a few countries and institutions. North America emerged as the leading contributor in this domain. Moreover, the study identified that the most prolific institutions were those with strong public health research groups. The accelerated speed of publications could ensure the

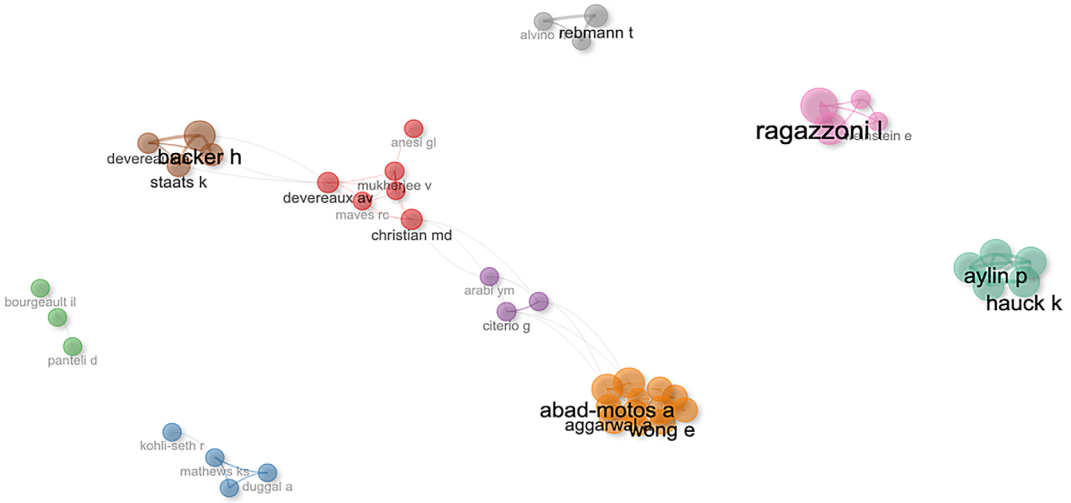

Figure 5. Author collaboration network analysis on medical surge capacity and response to the COVID-19 pandemic.

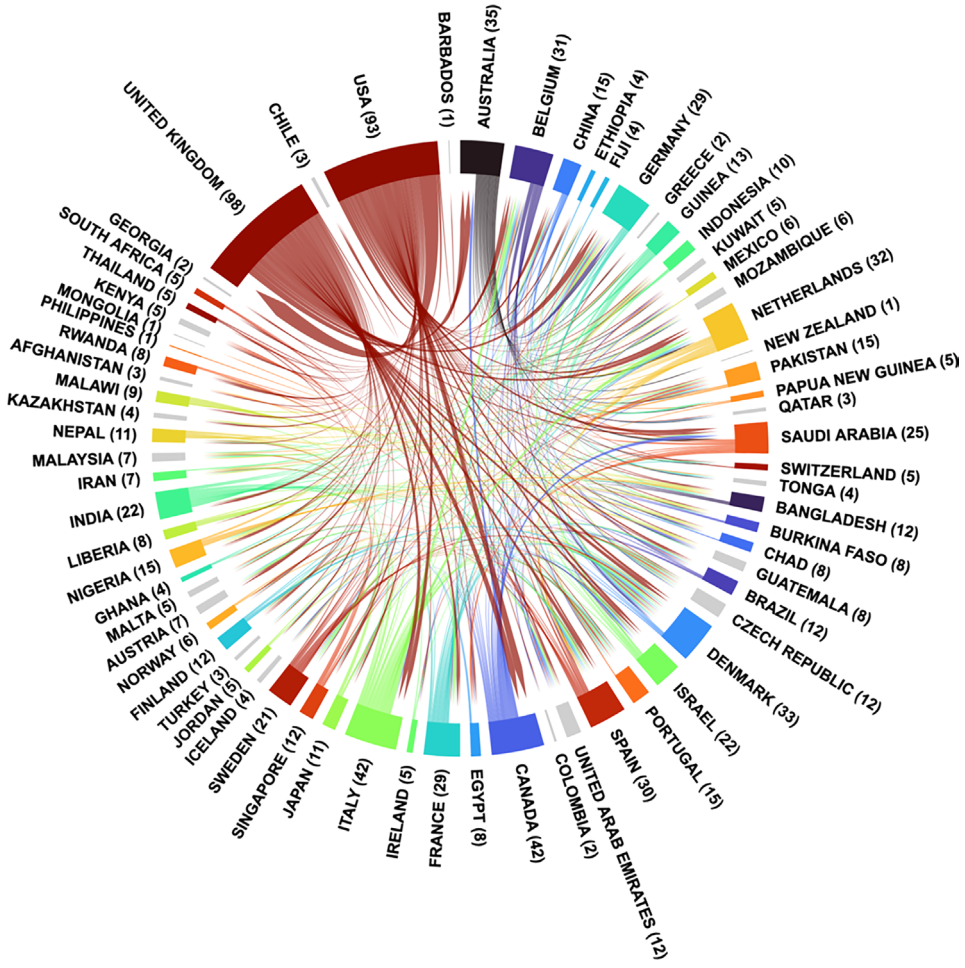

Figure 6. Global collaboration chord diagram on medical surge capacity and response to the COVID-19 pandemic.

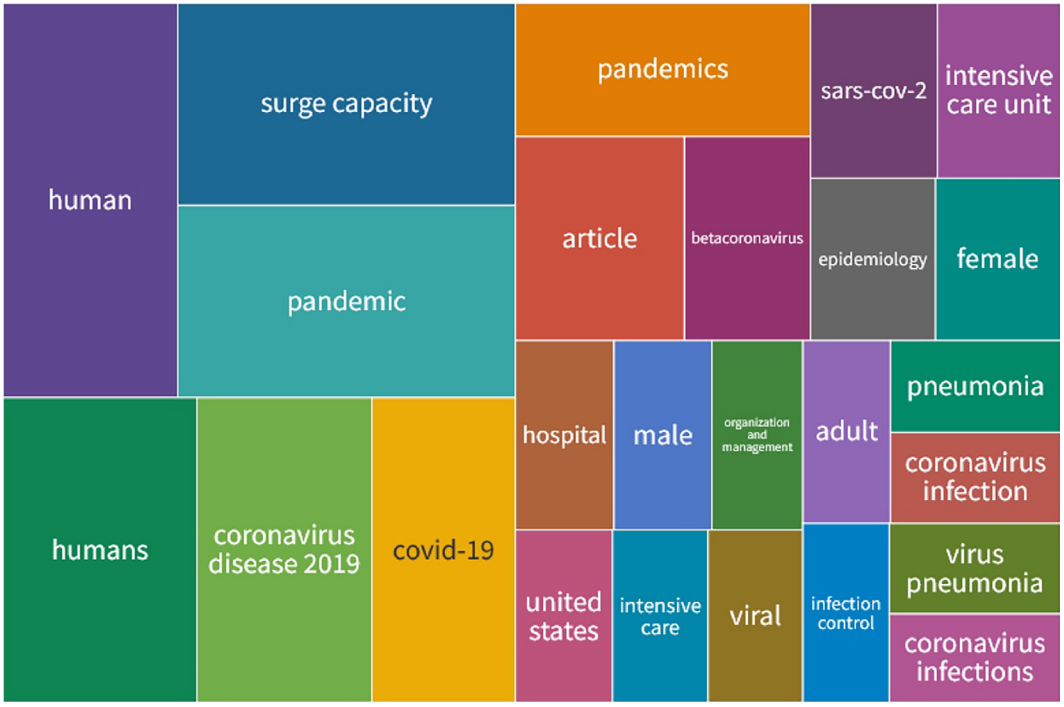

Figure 7. Main topics of research on medical surge capacity and response to the COVID-19 pandemic.

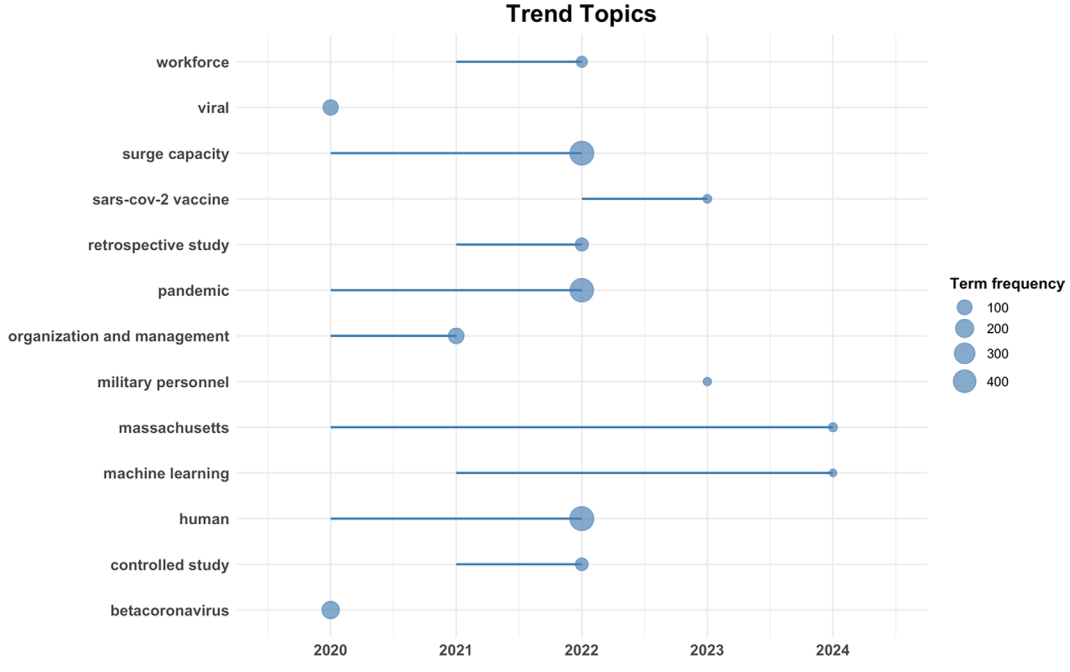

Figure 8. Trend topics of research on medical surge capacity and response to the COVID-19 pandemic.

prompt sharing of the new evidence; however, dissemination of a large volume of publications has also raised some concerns. Therefore, there is the need for a constant monitoring of the research publications regarding the time-trends, global contribution, international collaboration, and subjects of literature published during the pandemic. These insights into the characteristics of the current body of literature on COVID-19 can help policymakers develop strategies to respond appropriately to public health emergencies. The surge in publications during the early years of the pandemic can be attributed to the initial chaos and organizational challenges faced by health systems worldwide. As the pandemic unfolded, there was an urgent need to address the overwhelming demand for healthcare services, resulting in a spike in research on medical surge capacity. This trend is consistent with the findings of Lio et al., who highlighted the rapid implementation of personal protective measures and organizational changes in response to the pandemic (26). As health systems began to adapt and stabilize, the volume of research on this topic plateaued, reflecting a shift from immediate crisis response to longer-term strategies and adaptations. The prominence of certain countries and institutions in research output is likely linked to the strength and focus of their public health research groups. For instance, institutions in the USA, Canada, and the UK have well-established research programs in public health and emergency preparedness, positioning them to respond swiftly to the pandemic through research. This is supported by the findings of Ahmad et al., who noted that countries like South Korea and Vietnam, with prior experience in handling epidemics such as MERS and SARS, were better prepared and more prolific in their research output during COVID-19 (27). The COVID-19 pandemic prompted the implementation of various public health and social measures, which played crucial roles in mitigating the spread of the virus. The effectiveness of these measures, including mask-wearing, physical distancing, lockdowns, and travel-related restrictions, has been widely studied, with findings indicating varied success depending on context and implementation. Mask-wearing emerged as a critical non-pharmaceuti cal intervention during the pandemic. Studies have shown that it significantly reduced COVID-19 incidence and mortality (28). In densely populated areas, the emphasis on mask-wearing at home and in public spaces proved particularly effective, as highlighted by Nandonik et al. (29). Physical distancing measures also played a significant role in reducing transmission rates and were linked to reductions in both transmission and mortality, with studies in the U.S. and Iran showing significant decreases in COVID-19-related deaths (30,31). However, the success of these measures was context-dependent, as shown in the study by Bracke et al., which emphasized the need for neighborhood-specific responses in urban settings to maximize the impact of physical distancing (32). Lockdowns were another widely implemented measure, generally associated with reductions in both the incidence and mortality of COVID-19. Studies by Wang et al., Guzzetta et al., and Basu et al. found that countries with strict lockdowns experienced fewer new cases and lower transmission rates. This trend was observed in various countries, including China, Italy, and India, where lockdowns led to significant reductions in the virus's reproductive number (R0) (33–35). Bracke et al. further noted that the success of lockdowns was enhanced when cities adapted federal policies to local contexts, demonstrating the importance of flexible and agile governance in managing public health crises (32). Travel-related restrictions yielded mixed outcomes, reflecting the complexity of their impact. For instance, Emeto et al. noted minimal effects of border closures in certain African countries (36). The effectiveness of these measures was closely tied to their implementation and the specific contexts in which they were applied, underscoring the need for a tailored approach to travel-related interventions during pandemics. Vaccination is a crucial public health intervention for reducing the impact of a pandemic (37). Mass vaccination programmes against COVID-19, which were rolled out in many countries, successfully averted cases, hospitalisations, intensive care unit admissions, and deaths (38–41). Several studies emphasize that the most beneficial effect on public health arises from a comprehensive strategy that combines non-pharmaceutical interventions with mass vaccination of the population (42,43). Thus, the effectiveness of public health and social measures during the COVID-19 pandemic was influenced by various factors, including population

density, the specificity of the measures, and the context in which they were implemented. While some interventions, like mask-wearing and physical distancing, proved broadly effective, others, such as travel restrictions, had more variable outcomes. These findings highlight the importance of a context-specific approach in public health interventions, as well as the need for continuous evaluation and adaptation of these measures to ensure their effectiveness during future pandemics. The pandemic had a profound impact on healthcare systems, presenting significant challenges such as workforce burnout, logistical issues, and the need for rapid digitalization. The findings of this study align with those of Odiase et al., who emphasized the urgent need for strengthening healthcare systems, particularly in resource-limited settings like Ghana (44). Notably, the acceleration of digitalization and the increased recognition of the role of primary healthcare emerged as positive outcomes, as observed by Michalaki et al. (45). However, these gains were tempered by the negative effects of fatigue and burnout among healthcare providers, which remain critical concerns for future preparedness efforts. One noteworthy finding from our research was the prominence of military personnel as a trending topic in COVID-19-related research. This trend can be attributed to the critical role that military organizations played in pandemic response. Military forces were often mobilized to establish and operate field hospitals, provide logistical support, and ensure the continuity of essential services. For instance, Louri et al. illustrate how a military hospital in Bahrain rapidly converted a parking lot into a fully functional field intensive care unit to manage the surge in COVID-19 cases (46). Similarly, Tan et al. highlight the use of telemedicine in military medical centers to enhance healthcare delivery during the pandemic (47). In Netherlands, critically ill patients were transported to areas with vacant ICU capacity by military to alleviate the burden in highly impacted regions (8). These examples demonstrate the military's significant capacity to contribute to national and global healthcare responses, particularly in times of crisis. There's a dominance in publications from High Income Countries (HICs) with underrepresentation of Low- and Middle-Income Countries (LMICs) despite LMICs facing critical surge capacity difficulties. India's Oxygen surge demand and underdeveloped Oxygen logistics were highlighted during the COVID-19 pandemic (48,49). This could have led to Low tech surge solutions such as mobilizing Community Health Workers in LMICs been under looked compared to High tech surge solutions such as Machine Learning models and Artificial Intelligence models developed in HICs to predict ICU demand during COVID-19 pandemic (50–54). Post COVID-19 policy changes is a noteworthy finding. European Union's (EU) Health Emergency Preparedness and Response Authority (HERA) and Administration for Strategic Preparedness and Response (ASPR) in the US have made significant efforts to emphasize the importance of investing in surge manufacturing capacity to be more resilient during a future health catastrophe (55,56). For instance, HERA highlights that EU hasn't addressed many countermeasures such as manufacturing antivirals, diagnostic equipment and personal protective equipment (55). ASPR has implemented policies to increase medical surge capacity during public health catastrophes such as emergency resource allocation as well as for surge capacity in clinical trial competencies (56). This analysis has several limitations that must be acknowledged. First, it was based on a single database, which may not encompass the full scope of research on medical surge capacity during the COVID-19 pandemic. Additionally, the reliance on English-language publications restricts the generalizability of the findings, particularly in regions where English is not the primary language of scientific communication. As a result, research published in other languages or in regional journals may have been overlooked, potentially introducing bias towards countries with higher English proficiency and stronger international research networks. Language bias might also occur as a result of excluding non-English publications. Also the country of the first author's affiliation might not represent the site of the study, as the first author may conduct the study in another country or several countries. The analysis cited only accounted for the affiliating country of the first author. Major strengths of the study include identification of key contributors and trends by highlighting most productive authors, institutions and mostly cited publications while tracking shifts in research focus.

Findings also stress the importance of international collaboration, resilient healthcare systems and surge preparedness which offer insights for future pandemic preparedness.

Conclusion

In conclusion, this study provides valuable insights into global research trends in medical surge capacity during the COVID-19 pandemic. The findings underscore the critical importance of robust public health systems, international collaboration, and the ongoing need for investment in healthcare infrastructure and workforce resilience. Future research should aim to address the limitations identified in this study, particularly by incorporating a broader range of databases and considering publications in multiple languages. This approach will help ensure a more comprehensive understanding of global research efforts in this vital area.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g., consultancies, stock ownership, equity interests, patent/licensing, arrangement etc-) that might pose a conflict of interest in connection with the submitted article.

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References

1. Hasan MK, Nasrullah SM, Quattrocchi A, Arcos González P, Castro-Delgado R. Hospital surge capacity preparedness in disasters and emergencies: a systematic review. Public Health. 2023;225:12–21. doi:10.1016/j.puhe.2023.09.017
2. Medical Surge Capacity and Capabilities (MSCC) Handbook Chapter 1 [Internet]. Available from: https://aspr.hhs.gov/HealthCareReadiness/guidance/MSCC/Pages/Chapter1-Overview.aspx
3. Williams GA, Maier CB, Scarpetti G, et al. What strategies are countries using to expand health workforce surge capacity during the COVID-19 pandemic? Eurohealth. 2020;26(2):51–7.
4. Krylova O, Kazmi O, Wang H, Lam K, Logar-Henderson C, Gapanenko K. Estimating surge in COVID-19 cases, hospital resources and PPE demand with the interactive and locally-informed COVID-19 Health System Capacity Planning Tool. Int J Popul Data Sci. 2020;5(4):1710. doi:10.23889/ijpds.v5i4.1710
5. World Health Organization. Health emergency and disaster risk management framework. Geneva: World Health Organization; 2019. Available from: https://iris.who.int/handle/10665/326106
6. Global Preparedness Monitoring Board. Annual report 2019 [Internet]. Available from: https://www.gpmb.org/docs/librariesprovider17/default-document-library/annual-reports/gpmb-2019-annualreport-en.pdf
7. OECD. Ready for the next crisis? Investing in health system resilience. Paris: OECD Publishing; 2023. doi:10.1787/1e53cf80-en
8. Winkelmann J, Panteli D, Berger E, Busse R. Have we learnt the right lessons? Intensive care capacities during the COVID-19 pandemic in Europe. Eurohealth. 2022;28(1):–.
9. Berger E, Winkelmann J, Eckhardt H, et al. A country-level analysis comparing hospital capacity and utilisation during the first COVID-19 wave across Europe. Health Policy. 2022;126:373–81. doi:10.1016/j.healthpol.2021.11.009
10. Yamamoto T, Ozaki M, Kasugai D, Burnham G. Assessment of critical care surge capacity during the COVID-19 pandemic in Japan. Health Secur. 2021;19:479–87. doi:10.1089/hs.2020.0227
11. Irish Medical Organisation. General provision and availability of hospital beds. Dublin: Irish Medical Organisation; 2020 [Internet]. Available from: https://www.imo.ie/policy-international-affair/documents/General-Provision-and-Availability-of-Hospital-Beds-August-2020.pdf
12. Young PJ, Psirides A, Streat S. New Zealand's staffed ICU bed capacity and COVID-19 surge capacity. N Z Med J. 2021;134:8–10. PMID:34788267
13. Bekenova NB, Vochshenkova TA, Ablakimova N, et al. A bibliometric analysis of study of associations of certain genotypes with the cardiovascular form of diabetic neuropathy. Biomed Res Int. 2024;2024:6761451. doi:10.1155/2024/6761451
14. Ablakimova N, Smagulova GA, Rachina S, et al. Bibliometric analysis of global research output on antimicrobial resistance among pneumonia pathogens (2013–2023). Antibiotics (Basel). 2023;12(9):1411. doi:10.3390/antibiotics12091411
15. Zhylkybekova A, Koshmaganbetova GK, Zare A, et al. Global research on care-related burden and quality of life of informal caregivers for older adults: a bibliometric analysis. Sustainability. 2024;16(3):1020. doi:10.3390/su16031020

16. Kandel N, Chungong S, Omaar A, Xing J. Health security capacities in the context of COVID-19 outbreak: an analysis of International Health Regulations annual report data from 182 countries. Lancet. 2020;395:1047–53. doi:10.1016/S0140-6736(20)30553-5
17. Iuliano AD, Brunkard JM, Boehmer TK, et al. Trends in disease severity and health care utilization during the early Omicron variant period compared with previous SARS-CoV-2 high transmission periods, United States, December 2020–January 2022. MMWR Morb Mortal Wkly Rep. 2022;71:146–52.
18. Aziz S, Arabi YM, Alhazzani W, et al. Managing ICU surge during the COVID-19 crisis: rapid response. Intensive Care Med. 2020;46:1303–25. doi:10.1007/s00134-020-06092-5
19. Arabi YM, Murthy S, Webb S. COVID-19: a novel coronavirus and a novel challenge for critical care. Intensive Care Med. 2020;46:833–6. doi:10.1007/s00134-020-05955-1
20. Glasbey J, Ademuyiwa A, Adisa A, et al. Effect of COVID-19 pandemic lockdowns on planned cancer surgery for 15 tumour types in 61 countries: an international, prospective, cohort study. Lancet Oncol. 2021;22:1507–17. doi:10.1016/S1470-2045(21)00493-9
21. Weissman GE, Crane-Droesch A, Chivers C, et al. Locally informed simulation to predict hospital capacity needs during the COVID-19 pandemic. Ann Intern Med. 2020;173:21–8. doi:10.7326/M20-1260
22. Verelst F, Kuylen E, Beutels P. Indications for healthcare surge capacity in European countries facing an exponential increase in coronavirus disease (COVID-19) cases, March 2020. Euro Surveill. 2020;25(13):2000323. doi:10.2807/1560-7917.ES.2020.25.13.2000323
23. McCabe R, Schmit N, Christen P, et al. Adapting hospital capacity to meet changing demands during the COVID-19 pandemic. BMC Med. 2020;18:–. doi:10.1186/s12916-020-01781-w
24. Cheng FY, Joshi H, Tandon P, et al. Using machine learning to predict ICU transfer in hospitalized COVID-19 patients. J Clin Med. 2020;9(6):1668. doi:10.3390/jcm9061668
25. Kadri SS, Sun J, Lawandi A, et al. Association between caseload surge and COVID-19 survival in 558 U.S. hospitals, March to August 2020. Ann Intern Med. 2021;174:1240–51. doi:10.7326/M21-1213
26. Lio CF, Cheong HH, Lei CI, et al. Effectiveness of personal protective health behaviour against COVID-19. BMC Public Health. 2021;21(1):827. doi:10.1186/s12889-021-10680-5
27. Ahmad R, Atun RA, Birgand G, et al. Macro level influences on strategic responses to the COVID-19 pandemic: an international survey and tool for national assessments. J Glob Health. 2021;11:05011. doi:10.7189/jogh.11.05011
28. Leffler CT, Ing E, Lykins JD, Hogan MC, McKeown CA, Grzybowski A. Association of country-wide coronavirus mortality with demographics, testing, lockdowns, and public wearing of masks. Am J Trop Med Hyg. 2020;103(6):2400–11. doi:10.4269/ajtmh.20-1015
29. Nandonik AJ, Anik AI, Kabir ZN. Exploring varied experiences of three stakeholders of the COVID-19 pandemic. Risk Manag Healthc Policy. 2024;17:1827–33. doi:10.2147/RMHP.S460202
30. Guo C, Chan SHT, Lin C, et al. Physical distancing implementation, ambient temperature and COVID-19 containment: an observational study in the United States. Sci Total Environ. 2021;789:147876. doi:10.1016/j.scitotenv.2021.147876
31. Alimohamadi Y, Holakouie-Naieni K, Sepandi M, Taghdir M. Effect of social distancing on COVID-19 incidence and mortality in Iran since February 20 to May 13, 2020: an interrupted time series analysis. Risk Manag Healthc Policy. 2020;13:1695–700. doi:10.2147/RMHP.S265079
32. Bracke M, Molenaar J, Colliers A, et al. Evaluation study of the urban governance of the COVID-19 crisis in the city of Antwerp. BMC Public Health. 2024;24(1):2117. doi:10.1186/s12889-024-19569-5
33. Wang J, Liao Y, Wang X, et al. Incidence of novel coronavirus (2019-nCoV) infection among people under home quarantine in Shenzhen, China. Travel Med Infect Dis. 2020;37:101660. doi:10.1016/j.tmaid.2020.101660
34. Guzzetta G, Riccardo F, Marziano V, et al. Impact of a nationwide lockdown on SARS-CoV-2 transmissibility, Italy. Emerg Infect Dis. 2021;27(1):267–70. doi:10.3201/eid2701.202114
35. Basu D, Salvatore M, Ray D, et al. A comprehensive public health evaluation of lockdown as a non-pharmaceutical intervention on COVID-19 spread in India: national trends masking state level variations. medRxiv. 2020;2020.05.25.20113043. doi:10.1101/2020.05.25.20113043
36. Emeto TI, Alele FO, Ilesanmi OS. Evaluation of the effect of border closure on COVID-19 incidence rates across nine African countries: an interrupted time series study. Trans R Soc Trop Med Hyg. 2021;115(10):1174–83. doi:10.1093/trstmh/trab033
37. Oladapo RK, Obidiro OP, Oyetola AB, et al. COVID-19 vaccination in low and middle-income countries: creating a sustainable roadmap for promoting public health intervention. Int J Health Plann Manage. 2024;39(5):1612–25. doi:10.1002/hpm.3834
38. Thakkar K, Spinardi J, Kyaw MH, et al. Modelling the potential public health impact of different COVID-19 vaccination strategies with an adapted vaccine in Singapore. Expert Rev Vaccines. 2024;23(1):16–26. doi:10.1080/14760584.2023.2290931
39. Brault A, Hart A, Uribe P, et al. Direct impact of COVID-19 vaccination in Chile: averted cases, hospitalizations, ICU admissions, and deaths. BMC Infect Dis. 2024;24(1):467. doi:10.1186/s12879-024-09304-1
40. Sacco C, Mateo-Urdiales A, Petrone D, et al. Estimating averted COVID-19 cases, hospitalisations, intensive care unit admissions and deaths by COVID-19 vaccination, Italy, January –September 2021. Euro Surveill. 2021;26(47):2101001. doi:10.2807/1560-7917.ES.2021.26.47.2101001
41. Nie R, Abdelrahman Z, Liu Z, Wang X. Evaluation of the role of vaccination in the COVID-19 pandemic based on the data from the 50 U.S. states. Comput Struct Biotechnol J. 2022;20:4138–45. doi:10.1016/j.csbj.2022.08.009

42. Adeyinka DA, Neudorf C, Camillo CA, Marks WN, Muhajarine N. COVID-19 vaccination and public health countermeasures on variants of concern in Canada: evidence from a spatial hierarchical cluster analysis. JMIR Public Health Surveill. 2022;8(5):e31968. doi:10.2196/31968
43. Leung K, Wu JT, Leung GM. Effects of adjusting public health, travel, and social measures during the roll-out of COVID-19 vaccination: a modelling study. Lancet Public Health. 2021;6(9):e674–82. doi:10.1016/S2468-2667(21)00167-5
44. Odiase OJ, Gyamerah AO, Achana F, et al. Factors influencing healthcare workers' and health system preparedness for the COVID-19 pandemic: a qualitative study in Ghana. PLOS Glob Public Health. 2024;4(7):e0003356. doi:10.1371/journal.pgph.0003356
45. Michalaki F, Triantafillopoulou KM, Pagkozidis I, Tirodimos I, Dardavesis T, Tsimtsiou Z. The impact of COVID-19 pandemic on primary health care through health providers' eyes: a qualitative study of focus groups and individual interviews in Greece. Eur J Gen Pract. 2024;30:–. doi:10.1080/13814788.2024.2382218
46. Louri NA, Alkhan JA, Isa HH, et al. Establishing a 130-bed field intensive care unit to prepare for COVID-19 in 7 days in Bahrain Military Hospital. Disaster Med Public Health Prep. 2021;15:e34–43. doi:10.1017/dmp.2020.297
47. Tan NG, Yang LWY, Tan MZW, Chng J, Tan MHT, Tan C. Virtual care to increase military medical centre capacity in the primary health care setting: a prospective self-controlled pilot study of symptoms collection and telemedicine. J Telemed Telecare. 2022;28:603–12. doi:10.1177/1357633X20959579
48. Mirza M, Verma M, Sahoo SS, Roy S, Kakkar R, Singh DK. India's multi-sectoral response to oxygen surge demand during COVID-19 pandemic: a scoping review. Indian J Community Med. 2023;48(1):31–40. doi:10.4103/ijcm.ijcm_665_22
49. Garg S. Oxygen logistics in India: a pandemic response. Transp Res Procedia. 2025;82:2060–74. doi:10.1016/j.trpro.2024.12.172
50. Feroz AS, Khoja A, Saleem S. Equipping community health workers with digital tools for pandemic response in LMICs. Arch Public Health. 2021;79(1):1. doi:10.1186/s13690-020-00513-z
51. Ahmed S, Chase LE, Wagnild J, et al. Community health workers and health equity in low- and middle-income countries: systematic review and recommendations for policy and practice. Int J Equity Health. 2022;21:–. doi:10.1186/s12939-021-01615-y
52. Khatri RB, Endalamaw A, Erku D, et al. Preparedness, impacts, and responses of public health emergencies towards health security: qualitative synthesis of evidence. Arch Public Health. 2023;81(1):208. doi:10.1186/s13690-023-01223-y
53. Mutawa AM. Predicting intensive care unit admissions in COVID-19 patients: an AI-powered machine learning model. Big Data Cogn Comput. 2025;9(1):13. doi:10.3390/bdcc9010013
54. Hernández-Monsalves AH, Letelier P, Morales C, et al. A machine learning model for predicting intensive care unit admission in inpatients with COVID-19 using clinical data and laboratory biomarkers. Biomedicines. 2025;13(5):1025. doi:10.3390/biomedicines13051025
55. Centre for European Policy Studies. Health emergency response governance: in-depth analysis 2024 [Internet]. Available from: https://cdn.ceps.eu/wp-content/uploads/2024/02/CEPS-InDepthAnalysis-2024-04_Health-emergency-response-governance.pdf
56. Administration for Strategic Preparedness and Response. FY2025 congressional justification [Internet]. Available from: https://aspr.hhs.gov/AboutASPR/BudgetandFunding/Documents/FY2025/ASPR-cj.pdf

Correspondence:
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Svetlana Rachina, MD
Department of Hospital Therapy,
I. M. Sechenov First Moscow State Medical University,
119048, Moscow, Russia
E-mail: rachina_s_a@staff.sechenov.ru
ORCID: 0000-0002-3329-7846