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Editorial

The HPCDP Journal: celebrating a decade of impact

The HPCDP Journal Team

Introduction

Health Promotion and Chronic Disease Prevention in Canada (the HPCDP Journal) is uniquely positioned to serve diverse audiences by presenting valuable contributions to the field of public health from scientists within and outside of government.

The HPCDP Journal marking its 10th anniversary under the current name is an opportune time to reflect on how far the journal, the editorial team and the community of contributors have come.

Over the past decade, the journal's focus on key public health priorities has sharpened, with rapid responses to unprecedented health challenges and significant strides in promoting population health intervention research. In this editorial, the HPCDP Journal Team highlights some of the most transformative milestones and publications, including the expanded focus on chronic disease and risk factor surveillance, the deepened commitment to population health intervention research and the rapid pivot at the start of the COVID-19 pandemic to address its far-reaching impact on chronic disease and health equity in Canada.

Expanding our focus on chronic disease and risk factor surveillance

The HPCDP Journal has been instrumental in advancing chronic disease and risk factor surveillance in Canada by publishing research articles that address numerous topics—childhood overweight and obesity trends,[1] the environmental factors associated with autism spectrum disorder[2] and analyses of the prevalence and patterns of multimorbidity and their associated determinants,[3] among many others.

The journal also featured articles about the economic burden of chronic diseases, for example, diabetes.[4] Several of the papers shone a light on the progress made in understanding and measuring the complex interplay between movement behaviours and health, recognizing that physical activity, sedentary behaviour and sleep cannot be considered in isolation given their co-dependence.[5] Important scientific contributions that advance our understanding of how to conceptualize and measure positive mental health[6] have also been published.

Strengthening our focus on population health intervention research

A foundational development of the past decade has been the journal's concerted focus on population health intervention research, a crucial area for addressing complex public health issues. This shift aligns with the principles of the "Ottawa Statement from the Sparking Solutions Summit on Population Health Intervention Research."[7] We are proud to have joined other leading journals in signing this statement, underscoring the commitment to advancing research that goes beyond describing problems to actively explore solutions that can make a measurable difference in the health of people in Canada.

The Ottawa Statement also emphasized the importance of research that examines the wider social, environmental and policy-related determinants of health, rather than only addressing individual health behaviours.[7]

Over the past decade, the journal has published numerous manuscripts, theme issues and commentaries that reflect this commitment to supporting research on the impacts of interventions, the contexts in which they work best and who they benefit the most. For example, we have published research on the association of the built environment with different types of physical activities in adults[8] and the role of food policies in shaping dietary behaviours.[9] These studies represent the kind of transformative research that the Ottawa Statement[7] advocates. They exemplify how population health intervention research can offer solutions to Canada's most pressing public health challenges.

Thematic issues have also provided actionable evidence to inform practices, programs and policies aimed at addressing major chronic conditions and risk factors—from substance use to food environments[10] to climate change and health,[11] and the national opioid crisis.[12,13] We extend our sincere gratitude to all Guest Editors of the theme issues for their invaluable contributions. While most Guest Editors are from academia, the editorial process for a recent series on the unregulated drug toxicity crisis in Canada was enriched by the insights of and engagement with individuals with lived or living experience.[14] This marked a first for the journal, and an experience we intend to repeat.

Evidence reviews have emerged as a key article type in the HPCDP Journal, providing critical insights to inform policy, program design and practice. Several of these reviews, particularly those focused on public health interventions, have garnered

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significant recognition. For example, an overview of reviews on social media interventions to promote health equity[15] stands out as highly cited. The journal has also featured articles showcasing methodological innovations for measuring the impacts of interventions. Notable among these was a paper on the development of indicators to evaluate the effectiveness and outcomes of age-friendly communities in Canada,[16] providing a robust framework for assessing progress and informing future action.

To further bridge the gap between science and policy, the HPCDP Journal also introduced a new article type in 2015, namely evidence-informed policy briefs. These articles summarize high-quality, relevant and up-to-date research-based evidence on known benefits and harms of interventions. These briefs also suggest options, indicate the costs and barriers to policy implementation and suggest strategies to address these barriers. However, only four such policy briefs have been published to date, underscoring the ongoing challenges in knowledge translation within the public health research community and emphasizing the need to expand the evidence base through applied research studies in public health in Canada.

Responding to the COVID-19 pandemic: an unprecedented challenge

While the journal's focus on intervention research shifted gradually and strategically for most of the last decade, the COVID-19 pandemic presented an abrupt and all-encompassing challenge that necessitated immediate action. We promptly pivoted to address the broader health impacts of COVID-19, issuing a call for papers for an online-first publication model. The rapid response from the research community, in Canada and internationally, was remarkable. This response underscored the urgency of understanding the complex effects of the pandemic on population health. The HPCDP Journal has received 213 manuscripts on COVID-19 since March 2020, and so far 59 have been published.

The pandemic illuminated the interconnectedness of infectious diseases, chronic conditions and health inequities among people in Canada. COVID-19 affected not only the people who were infected but also individuals with pre-existing chronic conditions who faced disruptions in care and heightened risk due to strained health care systems. The pandemic also underscored the need for equity in the approach to health promotion and chronic disease prevention. COVID-19 laid bare the vulnerabilities of certain population groups—Indigenous communities, racialized groups and individuals with low income—who experienced higher rates of infection, poorer outcomes and greater barriers to health care.[17]

The HPCDP Journal responded by publishing the results of studies that analyzed, in different population groups, the indirect effects of the pandemic on health behaviours and chronic disease outcomes, including on mental health outcomes.[18]

The long-term impact of the COVID-19 pandemic on health extends beyond the immediate crisis, including the effects of post-COVID-19 condition,[19] with lasting consequences for chronic disease management and overall well-being. The disruptions in care, combined with changes in health behaviours and increased mental health challenges, have underscored the importance of long-term studies to fully understand these effects.

As we continue to address these challenges, effective dissemination of scientific findings will be critical to shaping equitable, evidence-based strategies that promote resilience and health equity across all communities.

Looking forward: a vision for the next decade

Looking ahead, we recognize the importance of continuing to publish research findings that are based on, and that foster, cross-disciplinary and cross-sectoral collaborations. The challenges we face in chronic disease prevention and health promotion cannot be addressed by the public health sector alone; they require partnerships across education, housing, transportation and social services to create environments that support healthy behaviours and reduce health disparities. Our special issue on social prescribing, published in 2024, contributes to this conversation,[20,21] as will the theme issue on natural experiments and built environments scheduled for release later this year.

In this context, the HPCDP Journal also welcomes contributions in emerging fields relevant to health promotion and chronic disease prevention, such as digital health and health technology, implementation science, the commercial determinants of health, big data and predictive analytics, as well as the intersections of infectious and chronic diseases through a One Health approach. These areas reflect the evolving landscape of public health and highlight the importance of innovative and integrative approaches to improving population health outcomes.

We are dedicated to strengthening the journal's role as a platform for research that places equity at its core. The pandemic exposed glaring health disparities and reinforced the critical need to address the social determinants of health. In the years ahead, we aim to publish research that goes beyond documenting these inequities to testing and evaluating interventions designed to reduce them. By prioritizing equity-driven research, we aspire to contribute to a future where everyone in Canada has the opportunity to attain optimal health and well-being.

The HPCDP Journal will also continue to publish vital research that leverages pan-Canadian surveillance systems, advancing our understanding of risk and protective factors and contributing to chronic disease prevention efforts across the country.

Finally, we recognize the importance of embracing innovation in our publishing practices to remain responsive to the evolving landscape of scientific communication. Advances in technology are transforming how research is conducted, shared and accessed, and we are committed to ensuring that *Health Promotion and Chronic Disease Prevention in Canada* stays at the forefront of these changes. As an open-access journal that publishes original research articles, we aim to explore practices that accelerate the dissemination of research findings and to adopt new formats that enhance engagement with published work. By continually evolving our practices, we strive to better meet the needs of readers and contributors while maximizing the impact of the research we publish.

References

1. Rao DP, Kropac E, Do MT, Roberts KC, Jayaraman GC. Childhood overweight and obesity trends in Canada. Health Promot Chronic Dis Prev Can. 2016;36(9):194-8. https://doi.org/10.24095/hpcdp.36.9.03

2. Ng M, de Montigny JG, Ofner M, Do MT. Environmental factors associated with autism spectrum disorder: a scoping review for the years 2003-2013. Health Promot Chronic Dis Prev Can. 2017;37(1):1-23. https://doi.org/10.24095/hpcdp.37.1.01

3. Roberts KC, Rao DP, Bennett TL, Loukine L, Jayaraman GC. Prevalence and patterns of chronic disease multimorbidity and associated determinants in Canada. Health Promot Chronic Dis Prev Can. 2015;35(6):87-94. https://doi.org/10.24095/hpcdp.35.6.01

4. Anja Bilandzic A, Laura Rosella L. The cost of diabetes in Canada over 10 years: applying attributable health care costs to a diabetes incidence prediction model. Health Promot Chronic Dis Prev Can. 2017;37(2):49-53. https://doi.org/10.24095/hpcdp.37.2.03

5. Tomasone JR, Janssen I, Saunders TJ, Duggan M, Jones R, Brouwers MC, et al. Timing of 24-hour movement behaviours: implications for practice, policy and research. Health Promot Chronic Dis Prev Can. 2022;42(4):170-4. https://doi.org/10.24095/hpcdp.42.4.05

6. Orpana H, Vachon J, Dykxhoorn J, McRae L, Jayaraman G. Monitoring positive mental health and its determinants in Canada: the development of the Positive Mental Health Surveillance Indicator Framework. Health Promot Chronic Dis Prev Can. 2017;37(4):1-10. https://doi.org/10.24095/hpcdp.36.1.01

7. Ottawa Statement from the Sparking Solutions Summit on Population Health Intervention Research: Ottawa, Ontario, Canada April 25, 2016. Can J Public Health. 2016;107(6):e492-6. https://doi.org/10.17269/CJPH.107.6061

8. McCormack GR. Neighbourhood built environment characteristics associated with different types of physical activity in Canadian adults. Health Promot Chronic Dis Prev Can. 2017;37(6):175-85. https://doi.org/10.24095/hpcdp.37.6.01

9. Potvin Kent M, Hatoum F, Wu D, Remedios L, Bagnato M. Benchmarking unhealthy food marketing to children and adolescents in Canada: a scoping review. Health Promot Chronic Dis Prev Can. 2022;42(8):307-18. https://doi.org/10.24095/hpcdp.42.8.01

10. Vanderlee L, L'Abbé M. Commentary – Food for thought on food environments in Canada. Health Promot Chronic Dis Prev Can. 2017;37(9):263-5. https://doi.org/10.24095/hpcdp.37.9.01

11. Cunsolo A, Harper SL. Editorial – Climate change and health: a grand challenge and grand opportunity for public health in Canada. Health Promot Chronic Dis Prev Can. 2019;39(4):119-21. https://doi.org/10.24095/hpcdp.39.4.01

12. Tam T. Commentary – Building the evidence base for sustained public health response to the opioid epidemic in Canada. Health Promot Chronic Dis Prev Can. 2018;38(6):221-2. https://doi.org/10.24095/hpcdp.38.6.01

13. Strang R. Commentary – Broadening our understanding of Canada's epidemics of pharmaceutical and contaminated street drug opioid-related overdoses. Health Promot Chronic Dis Prev Can. 2018;38(9):309-11. https://doi.org/10.24095/hpcdp.38.9.01

14. Young P, Burmeister C, Slaunwhite A, Palis H. Engagement of people with lived and living experience in the editorial process: reflections on the special series on the unregulated drug toxicity crisis in Canada. Health Promot Chronic Dis Prev Can. 2024;44(7/8):303-5. https://doi.org/10.24095/hpcdp.44.7/8.01

15. Welch V, Petkovic J, Pardo Pardo J, Rader T, Tugwell P. Interactive social media interventions to promote health equity: an overview of reviews. Health Promot Chronic Dis Prev Can. 2016;36(4):63-75. https://doi.org/10.24095/hpcdp.36.4.01

16. Orpana H, Chawla M, Gallagher E, Escaravage E. Developing indicators for evaluation of age-friendly communities in Canada: process and results. Health Promot Chronic Dis Prev Can. 2016 Oct;36(10):214-23. https://doi.org/10.24095/hpcdp.36.10.02

17. Public Health Agency of Canada. From risk to resilience – an equity approach to COVID-19. The Chief Public Health Officer of Canada's report on the state of public health in Canada 2020. Ottawa (ON): PHAC; 2020. Available from: https://www.canada.ca/content/dam/phac-aspc/documents/corporate/publications/chief-public-health-officer-reports-state-public-health-canada/from-risk-resilience-equity-approach-covid-19/cpho-covid-report-eng.pdf

18. Georgiades K. Expanding the evidence for population mental health in Canada: a call to action for evidence-informed policy and practice. Health Promot Chronic Dis Prev Can. 2021;41(11):321-4. https://doi.org/10.24095/hpcdp.41.11.01

19. Taher MK, Salzman T, Banal A, Morissette K, Domingo FR, Cheung AM, et al. Global prevalence of post-COVID-19 condition: a systematic review and meta-analysis of prospective evidence. Health Promot Chronic Dis Prev Can. 2025;45(3):112-38. https://doi.org/10.24095/hpcdp.45.3.02

20. Mulligan K, Card KG, Allison S. Social prescribing in Canada: linking the Ottawa Charter for Health Promotion with health care's Quintuple Aim for a collaborative approach to health. Health Promot Chronic Dis Prev Can. 2024;44(9):355-7. https://doi.org/10.24095/hpcdp.44.9.01

21. Mulligan K, Card KG, Allison S. Social prescribing in Canada: health promotion in action, 50 years after the Lalonde report. Health Promot Chronic Dis Prev Can. 2024;44(6):241-3. https://doi.org/10.24095/hpcdp.44.6.01

An update to this article is included at the end.

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Evidence synthesis

Global prevalence of post-COVID-19 condition: a systematic review and meta-analysis of prospective evidence

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This article has been peer reviewed.

Abstract

Introduction: We investigated the prevalence of new or persistent manifestations experienced by COVID-19 survivors at 3 or more months after their initial infection, collectively known as post-COVID-19 condition (PCC).

Methods: We searched four electronic databases and major grey literature resources for prospective studies, systematic reviews, authoritative reports and population surveys. A random-effects meta-analysis pooled the prevalence data of 22 symptoms and outcomes. The GRADE approach was used to assess the certainty of evidence. PROSPERO CRD42021231476.

Results: Of 20 731 identified references, 194 met our inclusion criteria. These studies followed 483 531 individuals with confirmed COVID-19 diagnosis over periods of up to 2 years. Most focused on adults, nearly two-thirds were conducted in Europe and 63% were of high or moderate quality. The supplementary search identified 17 systematic reviews, five authoritative reports and four population surveys that reported on PCC prevalence. Our analysis revealed that more than half of COVID-19 survivors experienced one or more symptoms more than a year after their initial infection. The most common symptoms were fatigue; dyspnea; memory, sleep or concentration disturbances; depression; and pain. Limitation in returning to work was the most common outcome. Prevalence tended to be higher among females, individuals hospitalized during their initial infection and those who experienced severe COVID-19 illness.

Conclusion: PCC presents a significant health burden, affecting some groups more than others. This information will help inform health care system policies and services for people living with PCC and those caring for them.

Highlights

- We searched for prospective studies of the prevalence of post-COVID-19 condition (PCC) published up to 15 July 2022 and systematic reviews, authoritative reports and population surveys published up to 8 December 2023.
- Through group and subgroup analyses, we pooled prevalence data from 483 531 adults and children with new or persistent symptoms at least 3 months after their confirmed SARS-CoV-2 infection.
- More than 50% of COVID-19 survivors experienced at least one PCC symptom up to 2 years after their initial infection.
- The most common symptoms were dyspnea, fatigue, pain and depression, and the most common outcome was not returning to work.

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Keywords: *post-COVID-19 condition, post-COVID condition, PCC, post-acute sequelae of COVID-19, PASC, Long COVID, COVID-19 Long-Hauler, COVID-19 recovery, long-term effects of COVID-19, prevalence, systematic review, prospective studies*

Introduction

Almost 5 years after the first reported case of "pneumonia of unknown etiology,"[1] more than 772 million individuals have been reported as infected with SARS-CoV-2, and COVID-19 disease has contributed to more than 7 million deaths.[2] While many COVID-19 survivors recover fully from their acute infection, others developed or continue to experience a number of symptoms or outcomes for various periods of time.

The World Health Organization defines post-COVID-19 condition (PCC) as new or persistent symptoms that first occur 3 or more months after confirmed or suspected COVID-19, last for a minimum of 2 months and cannot be attributed to any other cause.[3,4] The most commonly reported symptoms include fatigue, dyspnea, cognitive dysfunction, memory or sleep disturbances, cough, tachycardia, pain, disturbed smell or taste, depression, anxiety and fever.[3-6]

Although health authorities were mostly able to record numbers of COVID-19 cases, estimating the number of individuals who experience PCC symptoms is difficult, largely because of the lack of a universally accepted definition of PCC, which has more than 200 primary symptoms or conditions, also with different definitions and assessment methods.[3-6] Consequently, reported PCC prevalence varies widely, from less than 1% to more than 50%, across studies.[7-12] Also contributing to this variation is the use of estimates that include both suspected and confirmed cases, that are based on different study designs and that apply different outcome assessment methods.

Statistical models projected that, by the end of 2021, approximately 145 million individuals, representing 3.7% of the nearly 4 billion people estimated to have been infected with COVID-19, could have experienced PCC.[13] These models also projected that 15.1% of this population might continue to experience these symptoms for more than 1 year after their initial infection.[13,14]

Results from recent population surveys conducted to assess the overall prevalence of PCC symptoms among adults vary from 14.3% in the USA[15] to 6.8% in Canada[16] and 4.7% in Australia.[17] A 2023 national survey found that 1.6 million individuals in the United Kingdom, or 2.6% of the total population, reported experiencing PCC symptoms.[11] Multiple studies have found that females were more likely than males to report PCC symptoms.[11,15,17,18]

A 2023 Canadian study projected the burden of PCC on the health care system to be between CAD 7.8 and 50.6 billion, with the cost per case between CAD 1675 and 7340 and the reduction in quality-adjusted life years between 0.047 and 0.206 during the first year after the initial infection.[19] A 2022 US study estimated annual PCC health care costs to be between USD 43 and 172 billion and lost income due to PCC to be between USD 101 and 430 billion, to a total loss of USD 140 to 600 billion annually.[7] These estimates exclude costs related to disability services, social services and caregiver income loss.[7]

The objective of this current review is to systematically identify, examine and analyze the prospective epidemiological evidence on the prevalence of predefined PCC symptoms and outcomes that emerged or continued to persist 3 or more months after confirmed COVID-19 diagnosis.

Methods

Systematic review registration

The review protocol was registered in PROSPERO, the international prospective register of systematic reviews (CRD42021231476), and followed Cochrane guidance[20] and Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidance.[21]

Inclusion criteria

This systematic review focuses on prospective studies (cohort studies and clinical trials) because they establish exposure to COVID-19 prior to development of PCC, which increases our certainty on the causative relationship between the two; because of their robust methodology; and because of their minimal susceptibility to recall bias.[22-24] Included were primary, prospective, peer-reviewed studies, published in English or French, with a minimum of 50 participants who reported new or persistent symptoms or outcomes 12 or more weeks after the onset of a confirmed COVID-19 diagnosis. Excluded were studies that recruited participants based on existing PCC symptoms or outcomes, or after the acute phase resolution (4 weeks).

Symptoms or outcomes were selected via consensus reached during consultations with patient representatives, clinical experts and policy makers. These symptoms and outcomes were based on patient concerns, clinical relevance and impact on health care service delivery. The symptoms included fatigue, dyspnea, pain, cognitive impairment, major cardiovascular events, psychopathologies and sleep disturbances, while outcomes included mobility issues and functional impairment. (Refer to Appendix A in Supplementary Material I for the study selection and data collection process, and a list of excluded studies.)

Search strategy

We implemented a comprehensive search strategy, adapted from the National Institute for Health and Care Excellence (NICE) guideline on long COVID,[25] to identify original prospective studies investigating the prevalence of PCC symptoms and outcomes in people, irrespective of their sex, age, race or ethnicity, country of residence or any other factor. A librarian conducted a peer review and determined that this search strategy aligned with our search criteria.

The initial search, undertaken on 15 July 2022, retrieved studies published between 22 October 2020 and 15 July 2022 from MEDLINE, Embase, Cochrane CENTRAL, PsycINFO and major grey literature resources. We conducted an extended search, using the same search strategy, on 13 to 31 March 2023, to identify systematic reviews, authoritative reports and population surveys that reported evidence published after 15 July 2022 to ensure a comprehensive and up-to-date contextual understanding. We continued monitoring for authoritative reports and population surveys through 8 December 2023.

Study selection

Using the DistillerSR application (DistillerSR Inc., Ottawa, ON, CA),[26] we developed and piloted a title and abstract screening form

and a full-text examination form. These forms were piloted by multiple reviewers (AH, AMZ, CL, EC, FRD, KM, LB, AB, MKT, RC, TC and TS) and subsequently adjusted before their full-scale implementation. In each phase, two reviewers independently applied these forms to each study to assess conformance with the inclusion criteria. A single reviewer was sufficient to screen study titles and abstracts for potential relevance and move a reference to full-text screening, whereas two reviewers were required to exclude a study. Two reviewers were also required to exclude a citation or promote it to the next level during full-text examination. Any disagreements at the full-text screening stage were resolved through discussion.

Data extraction

Data extraction forms were created in advance of the review using DistillerSR.[26] These forms were used to capture key study characteristics, patient demographics and outcome data (outlined in Table 1, Appendix B in Supplementary Material I and in Supplementary Material II). One reviewer (AH, AMZ, CL, EC, FRD, KM, LB, AB, MKT, RC, TC or TS) conducted the initial data extraction for each study, while a second cross-checked the extracted information for accuracy and completeness.

Assessment of risk of bias

We conducted an assessment of risk of bias (ROB) using a modified version of the Joanna Briggs Institute (JBI) appraisal tool for prevalence studies.[27,28] In consultation with the authors of the JBI critical appraisal tool, we omitted some questions to prevent overlap with the criteria for assessing imprecision and indirectness as part of the assessment of certainty of evidence (COE). Each study was assessed for ROB using the following JBI critical appraisal checklist questions: "Was the sample frame appropriate to address the target population?"; "Were study participants sampled in an appropriate way?"; and "Was the response rate adequate, and if not, was the low response rate managed appropriately?"[28] Each outcome was assessed separately for ROB using the following JBI critical appraisal checklist questions: "Were valid methods used for the identification of the condition?"; and "Was the condition measured in a standard, reliable way for all participants?"[28] Responses to all the questions were either "yes" or "no."

The questions were then grouped into three domains: participants (population, sampling and response rate); outcome measures (identification and measurement); and statistics (reported data). Studies fully meeting the criteria within these domains were rated as having a low ROB, those partly meeting the criteria were rated as having a moderate ROB and those not meeting the criteria were rated as having a high ROB. Each study was assessed for ROB by one reviewer and validated by another (AH, AMZ, EC, FRD, KM, LB, AB, PR, RC, TC and TS), with a third resolving any disagreements (MKT). (For more details, refer to Appendix C in Supplementary Material I.)

Data analysis

Extracted data were collated, cleaned and standardized using Excel 2019 (Microsoft, Redmond, WA, US).[29] We introduced a new variable, "onset to follow-up," to try to harmonize the different follow-up periods across included studies. These follow-up periods describe the time between confirmation of COVID-19 diagnosis, onset of symptoms or patient recovery and follow-up assessment. For those studies that described follow-up assessments as starting from the time of patient recovery, we added 1 week to the reported period. For those studies that described follow-up assessments as starting from the time of hospital discharge, we added 2 weeks to the reported period.

To better understand changes in PCC prevalence over time, we grouped our prevalence data into these four follow-up periods: 12 to 26 weeks, 27 to 39 weeks, 40 to 52 weeks, and more than 1 year. Where a study reported multiple times on an outcome/symptom within the same period, we used the data from the longest follow-up period.

We conducted a series of meta-analyses for prevalence data using a random-effects model to allow for expected heterogeneity of the included studies.[20,21] In our primary

TABLE 1
Key study characteristics, patient demographics and outcome data in included studies (n = 194)

Major characteristics	Study design: cohort / randomized controlled trial
	Case management: hospital-based (ICU/ward) / community-based (outpatient/ambulatory) / mixed
	Diagnosis: lab / clinical / lab + clinical
Patient demographics	Country of residence
	Population group: adults / children / all ages; males / females
Symptoms[a]	Dyspnea
	Fatigue
	Palpitations/tachycardia
	Pain: arthralgia; chest pain; headache; myalgia
	Cognitive impairment: brain fog; cognitive impairment (unspecified); concentration disturbance; memory disturbance
	Clinical psychopathologies: anxiety; depression; PTSD
	Health-related quality of life: sleep disturbance (unspecified); insomnia
Outcomes[a]	Mobility problems; limitations in returning to work[b]; difficulties with self-care; difficulties performing daily activities

Abbreviations: PTSD, posttraumatic stress disorder; ICU, intensive care unit.

[a] Symptoms and outcomes were selected during consultations with patient representatives, clinical experts and policy makers, and were based on patient concerns, clinical relevance and impact on health care service delivery.

[b] "Did not return to work" and "unable to return to work" were reported separately by some studies. Collectively these are described as "limitations in returning to work."

analysis, we pooled the data for each symptom and outcome and follow-up period separately across studies. To explore the reasons for heterogeneity, we conducted subgroup analyses by ROB level (low or moderate versus high), study population (hospital-based, community-based, mixed) and continent.

Whenever sufficient data were available, we stratified the prevalence data by sex, severity of disease, case management (hospitalized versus ambulatory) and level of hospital care (intensive care unit [ICU] versus ward) during the initial infection. While we explored stratification by age, race or ethnicity, or pre-existing conditions, analysis was not always feasible because of limited availability of data. If multiple studies examined the same population, we included only the most recent publication in the meta-analysis.

We performed the analyses using the statistical software RStudio version 1.4.1106 (R Foundation for Statistical Computing, Vienna, AT).[30] We used the "metaprop" function from the "meta" package for the meta-analysis and the "forest.meta" function from the same package to generate the forest plots.

Assessment of certainty of evidence

Upon completing the meta-analysis, we assessed the COE for each symptom and outcome using a modified version of the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach[31,32] for prognostic studies (previously adopted by Righy et al.[33]). An experienced assessor (AMZ, FRD, KM, LB, MKT or PR) evaluated the evidence for each symptom or outcome for the total sample across all follow-up periods. These assessments were then validated by another team member; in the event of any discrepancies, discussion among assessors continued until agreement was reached.

Each symptom and outcome was evaluated across several domains: ROB, inconsistency, indirectness and imprecision. ROB, in particular, was assessed across all studies reporting on a specific symptom or outcome using the GRADE approach. Unlike the JBI ROB tool, which evaluates bias within individual studies and their symptoms and outcomes, the GRADE approach examines ROB across all studies for each symptom and outcome, categorizing it as "not serious," "serious" or "very serious."

In addition to ROB, inconsistency was assessed by examining variability in prevalence estimates across studies. Indirectness was evaluated based on the relevance of the study population to the research question, while imprecision was assessed by analyzing sample sizes. Each of these domains contributed to determining the overall COE for each symptom and outcome across the four follow-up periods, classified as "high," "moderate," "low" or "very low." (For more details on the GRADE assessment, refer to Appendix D in Supplementary Material I.)

Results

Our primary search identified 20 731 unique citations from the four databases and grey literature resources. Of these, 194 met the inclusion criteria (see Figure 1).

The extended search identified 17 systematic reviews, five authoritative reports and four population surveys published between 2021 and 2023.

Overview of studies

Except for two clinical trials,[34,35] all of the 194 included studies were observational prospective cohort studies. More than 60% (n = 120) of the included studies were conducted in seven countries, namely Italy,[36-65] China, [34,66-90] Spain,[91-112] the USA,[113-127] France,[128-136] Switzerland[137-145] and the United Kingdom,[146-154] in order of number of retrieved studies. Four percent of the studies (n = 7) were conducted in the Netherlands,[35,155-160,] 3% (n = 6) in Mexico,[161-166] 2.6% in Brazil,[167-171] Denmark,[172-176] Germany,[176-181] Sweden[182-186] and Turkey[187-191] (n = 5 each) and 2.1% in Belgium[192-195] and India[196-199] (n = 4 each). As well, 1.5% of the studies were conducted in Iran[200-202] and Poland[203-205] (n = 3 each) and 1.0% in Australia,[206,207] Israel, [208,209] Norway,[210,211] Pakistan,[212,213] Russia[214,215] and South Korea[216,217] (n = 2 each). A single study was conducted in Austria,[218] Chile,[219] Iraq,[220] Ireland,[221] Japan,[222] Saudi Arabia,[223] Serbia[224] and Singapore[225] each. Two studies were conducted in multiple countries.[226,227] None of the included studies were conducted in Canada.

Follow-up periods

Most studies (n = 106) covered the 12- to 26-week period following the initial infection. Fewer studies covered periods of 27 to 39 weeks (n = 39), 40 to 52 weeks (n = 22) or more than 1 year (n = 25).

Patient demographics

The retrieved studies examined a total of 483 531 individuals with confirmed COVID-19 over follow-up periods of up to 2 years. Infection of 82% of participants in the included studies was confirmed by positive polymerase chain reaction (PCR) test; confirmation of infection of the remaining 18% relied on clinical diagnosis or a combination of clinical and laboratory diagnoses.

As many as 95% of studies (n = 184) included only adult participants (> 18 years). Seven studies reported data for both adults and children combined,[78,84,128,151,175,183,196] two studies focused exclusively on children and adolescents (≤ 18 years)[185,214] and one study provided separate data for children.[215] More than two-thirds (70%; n = 136) of studies included participants who were hospitalized during their initial infection; 8% included nonhospitalized (or ambulatory) patients; and 22% included both populations. We estimated the fair representation of females to range between 45% and 55% of the total study population. In 51% of the included studies, females made up less than 45% of the study sample. (More details on the excluded and included studies are provided in appendices A and B in Supplementary Material I, respectively.)

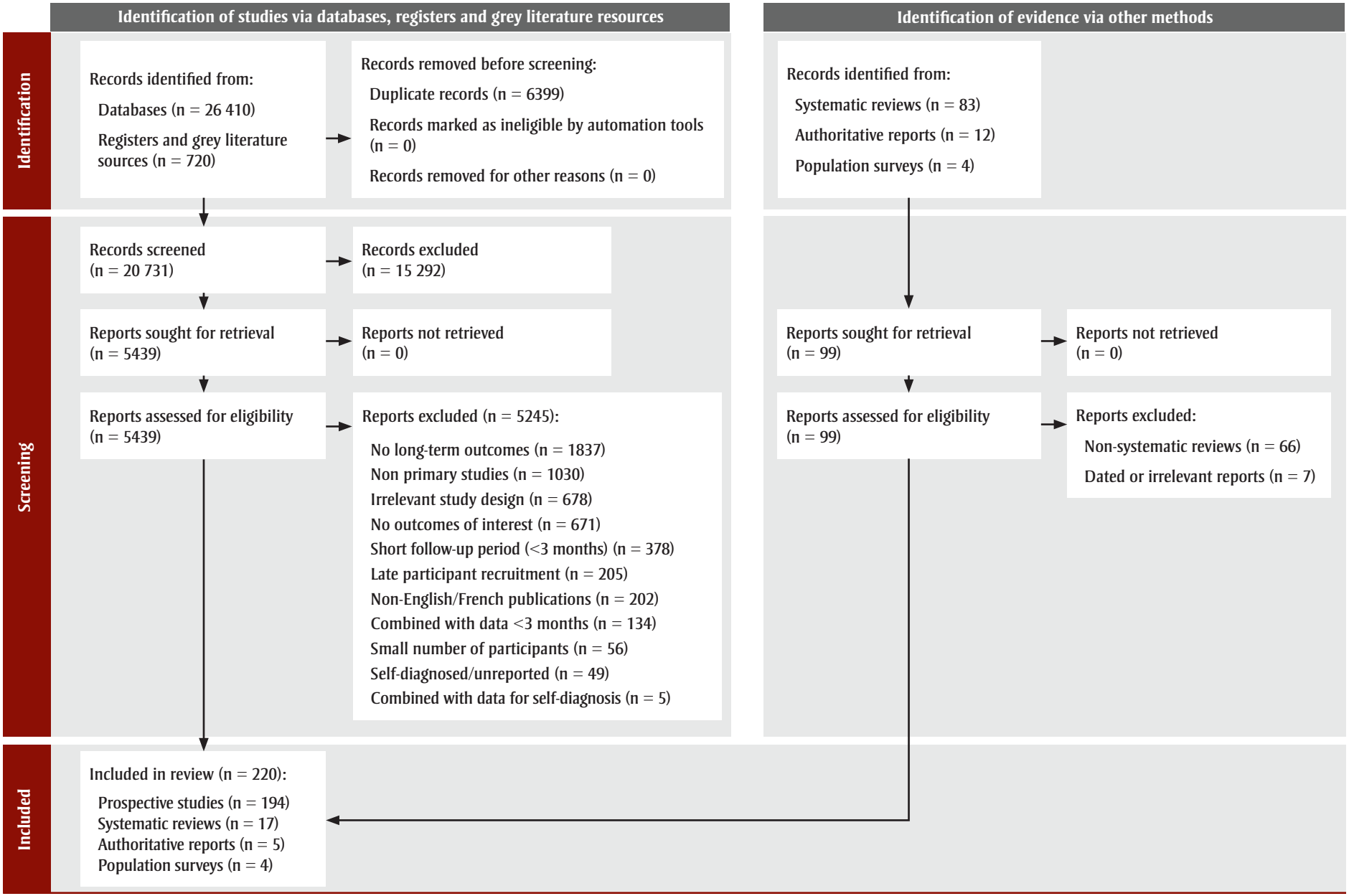
Risk of bias

Assessment of the included studies determined that 57% had moderate ROB, 39% had high ROB and 5% had low ROB. For most symptoms and outcomes, more than half of the reporting studies were considered to be of low or moderate ROB for these specific symptoms and outcomes. However, for anxiety, depression, posttraumatic stress disorder (PTSD), memory disturbance and mobility problems, more than half of the studies had high ROB. (ROB assessments are detailed in appendices B and C in Supplementary Material I.)

Certainty of evidence

The COE of 57% of assessments of symptoms or outcomes for the total sample across all follow-up periods was very low, of 39% was low and of 3% was moderate. Regarding ROB, most analyses demonstrated serious ROB, with 49% reflecting a

FIGURE 1
PRISMA 2020[21] flow diagram of included studies



Abbreviation: PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

full-point reduction and 14% reflecting a half-point reduction in certainty. In addition, 32% of the analyses were categorized as having a very serious ROB. In terms of inconsistency, the majority of assessments were also rated as serious, with 53% reflecting a full-point reduction and 31% reflecting a half-point reduction. Indirectness was also a significant factor, as 91% of the assessments were rated as serious due to the predominance of hospital-based populations in the supporting studies. Only 8% of analyses were supported by studies examining more balanced populations, such as community-based or mixed settings. Imprecision, assessed using the optimal information size criterion, was found to be non-serious in 93% of the analyses. However, 6% of the analyses were rated as serious due to unmet information size criterion thresholds. (For more information regarding the GRADE assessment, refer to Figures 3–6 and Appendix D in Supplementary Material I.)

Symptoms and outcomes

Across nearly all follow-up periods, more than half of the COVID-19 survivors reported experiencing one or more PCC symptoms: 56.5% (n = 14 615) at 12 to 26 weeks; 50.9% (n = 2764) at 27 to 39 weeks; and 77.6% (n = 2337) at over 1 year. At 40–52 weeks, the percentage reporting experiencing one or more PCC symptoms was lower, at 32.6% (n = 1198).

Fatigue (n = 101) and dyspnea (n = 98) were commonly reported in studies covering all follow-up periods. Other symptoms and outcomes were headache (n = 65), myalgia (n = 53), chest pain (n = 48) and palpitations/tachycardia (n = 41), although their relative rankings varied over time. Limitations in returning to work (n = 12) were the most commonly reported outcomes related to functional impairment in studies. (For an overview of the most prominent prevalence estimates, the number of studies contributing to each symptom or outcome as well as the level of heterogeneity of the studies, see Table 2; for more details, refer to Supplementary Material II.)

For the 12- to 26-week follow-up period, just over half of COVID-19 survivors reported experiencing one or more symptoms (56.50%, 32 studies, very low COE) (see Table 2 and Figure 2a). Fatigue (29.90%, 62 studies, very low COE) was the most prevalent symptom, followed by dyspnea (20.55%, 61 studies, low COE), depression (17.34%, 20 studies, very low COE), unspecified sleep disturbance (16.74%, 23 studies, very low COE) and anxiety (16.68%, 24 studies, very low COE). Limitations in returning to work was the most prevalent functional outcome during this period (see Table 2 and Figure 2b).

For the 27- to 39-week follow-up period, half of the COVID-19 survivors experienced one or more symptoms (50.89%, 9 studies, very low COE) (see Table 2 and Figure 3a). Depression was the most prevalent symptom (40.42%, 2 studies, very low COE) followed by fatigue (28.38%, 25 studies, very low COE), anxiety (23.93%, 4 studies, low COE), unspecified cognitive impairment (22.29%, 4 studies, moderate COE), unspecified sleep disturbance (17.09%, 8 studies, low COE) and dyspnea (14.81%, 22 studies, low COE). Limitations in returning to work was the most prevalent functional outcome during this period (see Table 2 and Figure 3b).

For the 40- to 52-week follow-up period, nearly one-third of COVID-19 survivors reported experiencing one or more symptoms (32.64%, 4 studies, low COE) (see Table 2 and Figure 4a). The most prevalent symptom was fatigue (30.70%, 12 studies, low COE) followed by dyspnea (16.06%, 15 studies, low COE), depression (15.71%, 3 studies, very low COE), PTSD (14.36%, 2 studies, very low COE), anxiety (14.12%, 3 studies, very low COE) and unspecified sleep disturbance (13.78%, 6 studies, very low COE). The most prevalent functional outcomes were limitations in returning to work and mobility problems (see Table 2 and Figure 4b).

In the follow-up period of more than 1 year, most COVID-19 survivors experienced one or more symptoms (77.64%, 6 studies, very low COE) (see Table 2 and Figure 5a). The most prevalent symptom was concentration disturbance (29.88%, 6 studies, low COE) followed by sleep disturbance (29.42%, 10 studies, low COE), fatigue (26.90%, 19 studies, very low COE), depression (18.45%, 3 studies, very low COE), anxiety (18.33%, 8 studies, low COE) and dyspnea (15.62%, 18 studies, very low COE). The most prevalent functional outcomes were inability to return to work (37.50%, 1 study, very low COE), not returning to work (17.27%, 3 studies, low COE) and difficulties performing daily activities (8.7%, 6 studies, very low COE) (see Table 2 and Figure 5b).

Studies involving children and adolescents

Two included studies explored PCC prevalence in children and adolescents (≤ 18 years) only.[185,214] Fatigue was the most common symptom, with prevalence from 10.7% to 14.6% at more than 4 to 5 months of follow-up. [185,214] Osmanov et al.[214] also reported increased prevalence of sleep disturbance (6.9%) and sensory problems (5.6%) among previously hospitalized children at more than 5 months of follow-up. Pazukhina et al.[215] examined all age groups and reported a PCC prevalence of 20% in children (median age: 9.5 years) at the 6-month follow-up, with fatigue the most common symptom (9%).

Subgroup analyses

Results of the subgroup analyses suggest that certain populations may have experienced a greater PCC burden than others (see tables and forest plots in Supplementary Material II). Higher point prevalence was reported among females than males for most symptoms and functional outcomes, with the exception of anxiety, depression, arthralgia, insomnia and mobility problems for some follow-up periods, although often these were not statistically significant (i.e. the confidence intervals overlapped for the point estimates). Higher pooled prevalence was also often observed with increasing severity of the disease or with hospitalization or ICU admission during the initial infection. However, in some cases those who were not hospitalized had higher point prevalence of mobility problems, difficulties with self-care, pain and sleep disturbance. In addition, many of these comparisons were not statistically significant.

Discussion

This systematic review includes 194 prospective studies that explored the prevalence of selected PCC symptoms and outcomes. Together, these studies examined a total of 483 531 individuals with confirmed COVID-19 over follow-up periods of up to 2 years. This review is the first to stratify reported prevalence data in four distinct follow-up periods after the initial infection to examine the trajectory of PCC prevalence over time.

TABLE 2
Pooled prevalence estimates[a] for the assessed PCC symptoms and outcomes[b] with GRADE-assessed certainty of evidence at different follow-up periods

Symptom / outcome	Value	Follow-up period			
		12–26 weeks	27–39 weeks	40–52 weeks	> 1 year
Symptom					
General					
≥1 symptoms	Pooled prevalence estimate, % (95% CI)	56.52 (47.18–65.42)	50.89 (33.53–68.03)	32.64 (19.64–49.00)	77.64 (52.23–91.69)
	I^2, %	99	98	96	99
	No. of studies, n	32	9	4	6
	COE	Very low	Very low	Low	Very low
Dyspnea	Pooled prevalence estimate, % (95% CI)	20.55 (13.64–29.76)	14.81 (11.41–19.01)	16.06 (11.60–21.82)	15.62 (8.76–26.31)
	I^2, %	100	94	96	99
	No. of studies, n	61	22	15	18
	COE	Low	Low	Low	Very low
Fatigue	Pooled prevalence estimate, % (95% CI)	29.90 (19.20–43.50)	28.38 (21.12–36.96)	30.70 (19.40–44.90)	26.90 (18.20–37.70)
	I^2, %	100	98	98	99
	No. of studies, n	62	26	12	19
	COE	Very low	Very low	Low	Very low
Palpitations/ tachycardia	Pooled prevalence estimate, % (95% CI)	7.63 (4.76–12.03)	7.01 (4.36–11.08)	3.35 (1.72–6.44)	6.73 (3.96–11.21)
	I^2, %	97	92	88	96
	No. of studies, n	20	11	7	13
	COE	Very low	Very low	Very low	Very low
Pain					
Chest pain	Pooled prevalence estimate, % (95% CI)	7.52 (5.22–10.74)	6.02 (3.65–9.77)	4.96 (3.55–6.88)	9.61 (5.94–15.20)
	I^2, %	97	93	74	95
	No. of studies, n	31	14	6	8
	COE	Very low	Low	Low	Very low
Headache	Pooled prevalence estimate, % (95% CI)	8.12 (6.31–10.39)	8.32 (5.12–13.26)	4.59 (2.42–8.55)	7.30 (4.04–12.85)
	I^2, %	95	95	91	97
	No. of studies, n	45	13	6	14
	COE	Low	Low	Low	Very low
Arthralgia	Pooled prevalence estimate, % (95% CI)	12.66 (8.79–17.9)	12.66 (6.39–23.52)	11.70 (7.95–16.91)	10.21 (4.81–20.37)
	I^2, %	98	98	92	97
	No. of studies, n	25	9	6	7
	COE	Very low	Low	Low	Very low
Myalgia	Pooled prevalence estimate, % (95% CI)	13.32 (10.18–17.23)	5.64 (3.13–9.95)	4.31 (2.35–7.79)	12.03 (5.48–24.37)
	I^2, %	97	93	85	99
	No. of studies, n	34	11	5	11
	COE	Very low	Very low	Low	Very low
Cognitive impairment					
Cognitive impairment (unspecified)	Pooled prevalence estimate, % (95% CI)	6.74 (1.16–30.85)	22.29 (17.98–27.30)	12.66 (5.38–26.99)	10.96 (2.60–36.23)
	I^2, %	100	13	95	95
	No. of studies, n	8	4	5	2
	COE	Very low	Moderate	Low	Low
Memory disturbance	Pooled prevalence estimate, % (95% CI)	10.42 (6.46–16.41)	12.97 (5.03–29.54)	5.20 (3.51–7.64)	13.07 (3.89–35.82)
	I^2, %	98	99	0	99
	No. of studies, n	22	10	2	7
	COE	Very low	Very low	Low	Very low

Continued on the following page

TABLE 2 (continued)
Pooled prevalence estimates[a] for the assessed PCC symptoms and outcomes[b] with GRADE-assessed certainty of evidence at different follow-up periods

Symptom / outcome	Value	Follow-up period			
		12–26 weeks	27–39 weeks	40–52 weeks	> 1 year
Concentration disturbance	Pooled prevalence estimate, % (95% CI)	15.52 (8.80–25.89)	11.85 (4.37–28.34)	6.39 (3.36–11.81)	29.88 (12.07–56.96)
	I^2, %	98	99	71	99
	No. of studies, n	15	10	2	6
	COE	Very low	Very low	Low	Low
Brain fog	Pooled prevalence estimate, % (95% CI)	8.47 (2.33–26.42)	9.85 (1.67–41.19)	–[c]	2.70 (1.90–3.50)
	I^2, %	99	99	–	NA
	No. of studies, n	5	4	–	1
	COE	Very low	Very low	–	Low
Clinical psychopathologies					
Anxiety	Pooled prevalence estimate, % (95% CI)	16.68 (12.48–21.95)	23.93 (3.97–70.52)	14.12 (2.99–46.74)	18.33 (13.03–25.16)
	I^2, %	96	98	98	93
	No. of studies, n	24	4	3	8
	COE	Very low	Low	Very low	Low
Depression	Pooled prevalence estimate, % (95% CI)	17.34 (13.35–22.23)	40.42 (16.35–70.19)	15.71 (7.10–31.27)	18.45 (2.81–63.86)
	I^2, %	94	93	95	98
	No. of studies, n	20	2	3	3
	COE	Very low	Very low	Very low	Very low
PTSD	Pooled prevalence estimate, % (95% CI)	15.11 (11.18–20.11)	8.59 (5.99–12.17)	14.36 (2.53–51.96)	6.22 (3.2–11.75)
	I^2, %	93	0	98	84
	No. of studies, n	19	4	2	4
	COE	Low	Low	Very low	Low
Health-related quality of life					
Sleep disturbance (unspecified)	Pooled prevalence estimate, % (95% CI)	16.74 (11.63–23.51)	17.09 (9.74–28.26)	13.78 (7.50–23.97)	29.42 (21.29–39.11)
	I^2, %	98	96	96	97
	No. of studies, n	23	8	6	10
	COE	Very low	Low	Very low	Low
Insomnia	Pooled prevalence estimate, % (95% CI)	11.79 (7.76–17.52)	10.29 (4.78–20.78)	6.06 (2.13–16.05)	9.93 (4.2–21.71)
	I^2, %	95	95	92	92
	No. of studies, n	12	5	3	3
	COE	Very low	Very low	Very low	Low
Outcome					
Mobility problems	Pooled prevalence estimate, % (95% CI)	20.58 (3.12–67.62)	31.81 (20.11–46.36)	8.93 (7.31–10.55)	5.98 (2.03–16.34)
	I^2, %	100	84	NA	93
	No. of studies, n	8	4	1	2
	COE	Very low	Very low	Moderate	Very low
Did not return to work[d]	Pooled prevalence estimate, % (95% CI)	34.86 (23.44–48.33)	36.89 (24.29–51.56)	11.22 (8.96–14.02)	17.27 (8.33–32.41)
	I^2, %	89	51	0	83
	No. of studies, n	5	2	2	3
	COE	Low	Very low	Moderate	Low
Difficulties performing daily activities	Pooled prevalence estimate, % (95% CI)	20.19 (9.72–37.28)	30.38 (21.26–41.37)	0.37 (0.03–4.77)	8.66 (4.21–17.01)
	I^2, %	96	92	85	95
	No. of studies, n	10	9	2	6
	COE	Low	Low	Low	Very low

Continued on the following page

TABLE 2 (continued)
Pooled prevalence estimates[a] for the assessed PCC symptoms and outcomes[b] with GRADE-assessed certainty of evidence at different follow-up periods

Symptom / outcome	Value	Follow-up period			
		12–26 weeks	27–39 weeks	40–52 weeks	> 1 year
Difficulties with self-care	Pooled prevalence estimate, % (95% CI)	12.72 (3.36–37.94)	23.09 (6.41–56.83)	2.71 (0.74–9.45)	1.27 (0.79–2.03)
	I^2, %	98	96	90	0
	No. of studies, n	7	4	2	2
	COE	Very low	Very low	Very low	Low
Unable to return to work[d]	Pooled prevalence estimate, % (95% CI)	38.24 (17.80–63.90)	44.29 (32.65–55.92)	33.33 (20.76–45.91)	37.50 (24.82–50.18)
	I^2, %	93	NA	NA	NA
	No. of studies, n	3	1	1	1
	COE	Very low	Very low	Very low	Very low

Abbreviations: CI, confidence interval; COE, certainty of evidence; GRADE, Grading of Recommendations, Assessment, Development, and Evaluations; I^2, statistic for assessing heterogeneity; NA, not applicable; PCC, post-COVID condition; PTSD, posttraumatic stress disorder.

[a] Using total samples.

[b] Symptoms and outcomes were selected during consultations with patient representatives, clinical experts and policy makers, and were based on patient concerns, clinical relevance and impact on health care service delivery.

[c] No studies were identified for this outcome at this follow-up period.

[d] "Did not return to work" and "unable to return to work" were reported separately by some studies. Collectively these are described as "limitations in returning to work."

At least half of the COVID-19 survivors reported one or more PCC symptoms across nearly all follow-up periods. The pooled prevalence estimate for one or more symptoms was highest for the more-than-1-year period. However, whether certain sample characteristics (e.g. higher proportion of hospitalized patients) influenced this increase could not be fully explored because of the limited number of studies contributing to this outcome.

Our analysis showed that fatigue (26.90%–30.70%), dyspnea (14.81%–20.55%), clinical psychopathologic symptoms (6.22%–40.42%), sleep disturbance (13.78%–29.42%), memory disturbance (5.20%–13.07%), concentration disturbance (6.39%–29.88%) and pain (4.31%–13.32%) were the most prevalent symptoms. Although subgroup analyses could not be performed for all follow-up periods because of the insufficient number of studies, we often observed higher point prevalence (not always statistically significantly higher) in the following subgroups: females; individuals who were hospitalized or admitted to the ICU during acute illness; and individuals who experienced severe COVID-19.

The lower PCC prevalence among children and adolescents compared to adults was evident across the few identified studies that examined this age group,[185,214,215,228] which aligns with other systematic reviews and reports.[5,6,229] These publications reported that common symptoms among children include fatigue, anosmia, headache, anxiety, anorexia, earache/tinnitus and sore eyes.[5,6,229] A 2021 population survey conducted in the United Kingdom found self-reported prevalence of PCC to range from 0.16% among those aged 2 to 11 years to 0.65% among those aged 12 to 16 years and 1.22% among those aged 17 to 24 years.[6,230]

Most of the studies in this review examined only hospitalized populations, which precludes drawing useful comparisons with healthy control groups. As a result, our prevalence estimates may be overestimated, as we could not adjust for baseline prevalence rates of non-PCC-related symptoms. In addition, more than two-thirds of the study populations were in European countries, and there was less information on PCC prevalence in other parts of the world.

Many studies did not report major risk factors such as age, sex, race or ethnicity, socioeconomic status or pre-existing health conditions, and thus were omitted from the subgroup analyses. This lack of reporting hindered our ability to compare PCC prevalence between males and females or children and adults, for example. We also observed considerable variations in the ways symptoms and outcomes were defined or assessed across the studies.

The heterogeneity of each outcome across the included studies varied widely, with 40% of analyses demonstrating levels of 75% or greater. When investigating potential sources of bias, we noted concerns to do with sampling of study participants, adequacy of participants' response rates and approaches to managing low response rates. We also noted biases regarding the validity of methods used to diagnose COVID-19 and to assess the symptoms and outcomes across different studies.

In-depth GRADE assessment showed that 99% of the outcomes analyzed had serious or very serious ROB. Limiting the assessments to studies with low to moderate ROB would have substantially enhanced the overall GRADE levels. In nearly one-third of analyses, heterogeneity could be explained in part by one or more subgroup analyses. Indirectness was deemed serious in 90% of analyses because of the predominant focus on hospitalized populations, which may have contributed to higher prevalence estimates.

Results of the 2023 Canadian COVID-19 Antibody and Health Survey (CCAHS) revealed that nearly 20% of COVID-19 survivors (6.8% of adults in Canada) experienced PCC symptoms.[16] Of this group, nearly 80% continued to experience these symptoms for 6 months or longer, and more than 40% for a year or longer.[16] Earlier results reported that prevalence was higher among females, those initially hospitalized for severe COVID-19 and individuals with pre-existing chronic conditions.[18] Common symptoms reported from

FIGURE 2A
Pooled prevalence estimates of PCC symptoms at 12–26 weeks after confirmed COVID-19

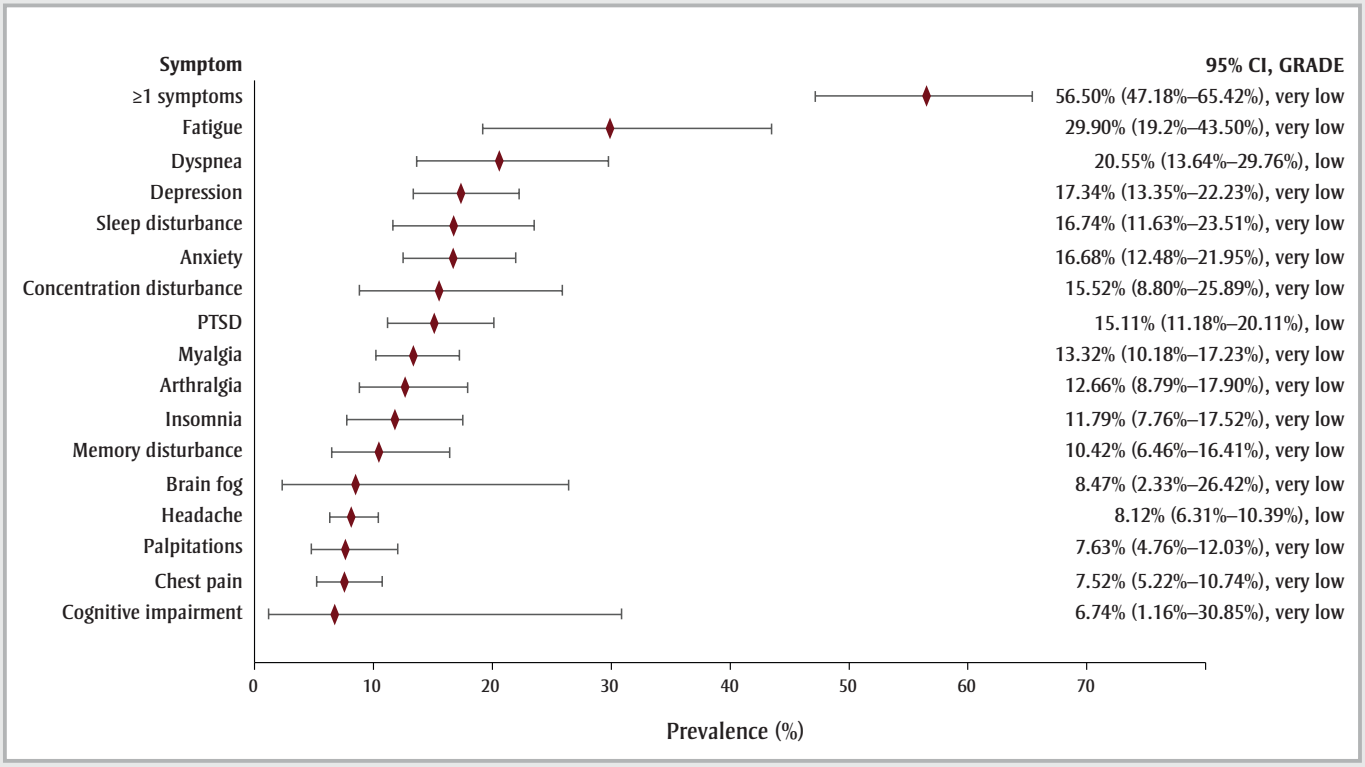
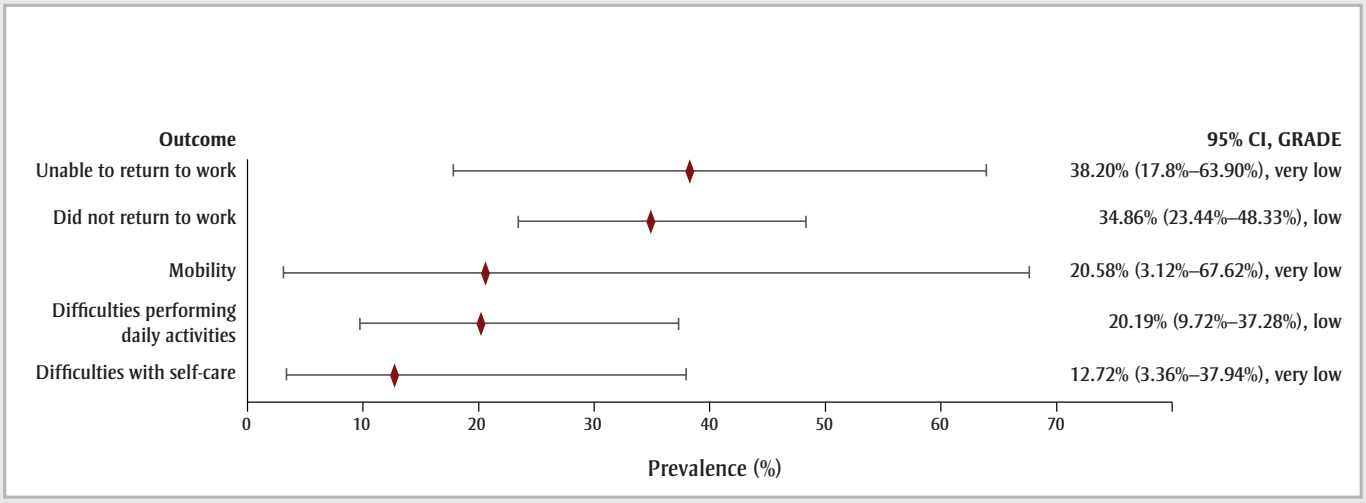


FIGURE 2B
Pooled prevalence estimates of PCC outcomes at 12–26 weeks after confirmed COVID-19



Abbreviations: CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Development, and Evaluations; PCC, post-COVID-19 condition; PTSD, posttraumatic stress disorder.

Notes: Error bars represent 95% CIs. GRADE certainty of evidence levels are high, moderate, low or very low.

FIGURE 3A
Pooled prevalence estimates of PCC symptoms at 27–39 weeks after confirmed COVID-19

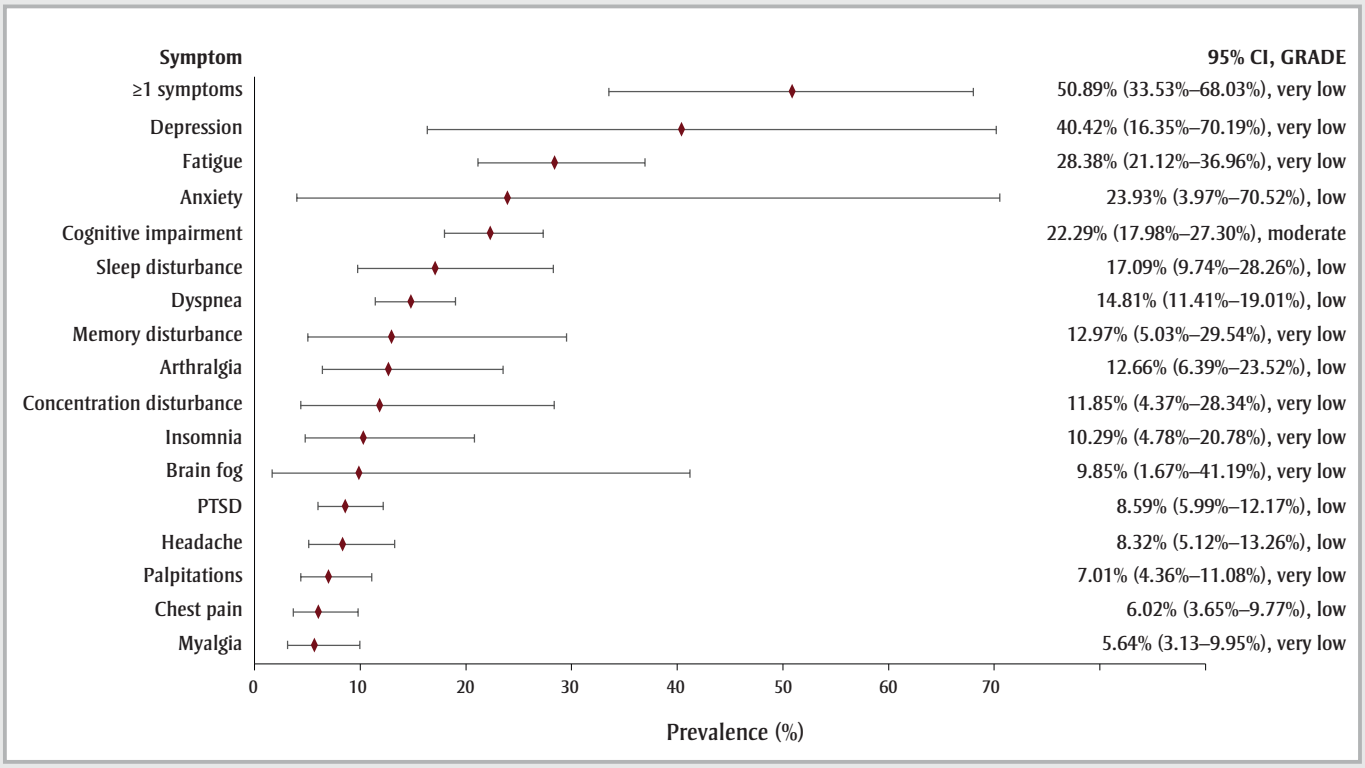
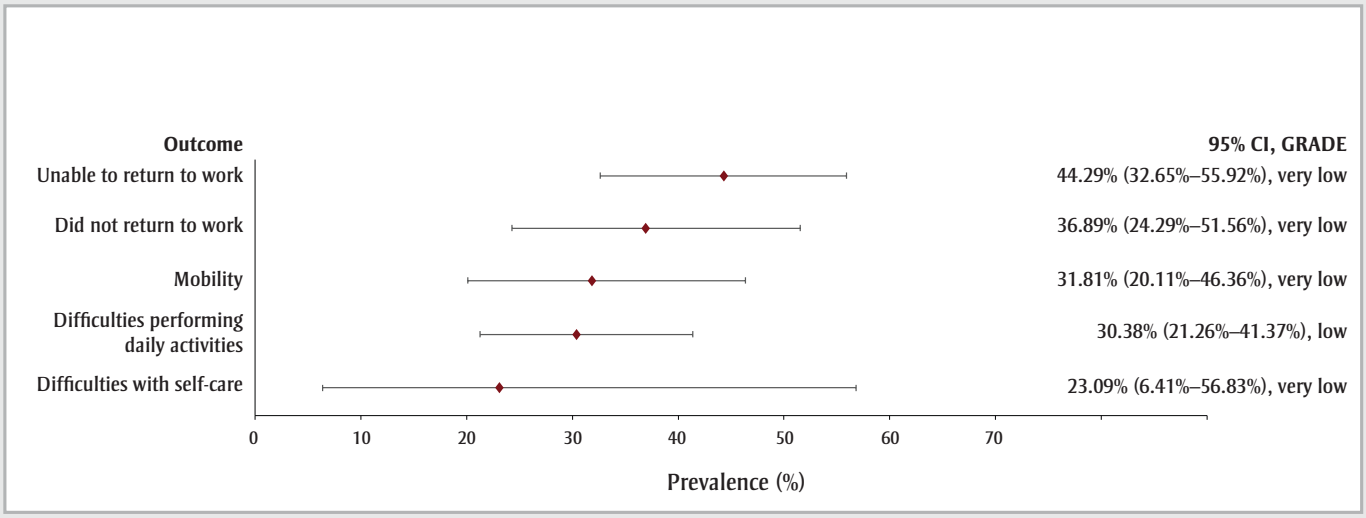


FIGURE 3B
Pooled prevalence estimates of PCC outcomes at 27–39 weeks after confirmed COVID-19



Abbreviations: CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Development, and Evaluations; PCC, post-COVID-19 condition; PTSD, posttraumatic stress disorder.

Notes: Error bars represent 95% CIs. GRADE certainty of evidence levels are high, moderate, low or very low.

FIGURE 4A
Pooled prevalence estimates of PCC symptoms at 40–52 weeks after confirmed COVID-19

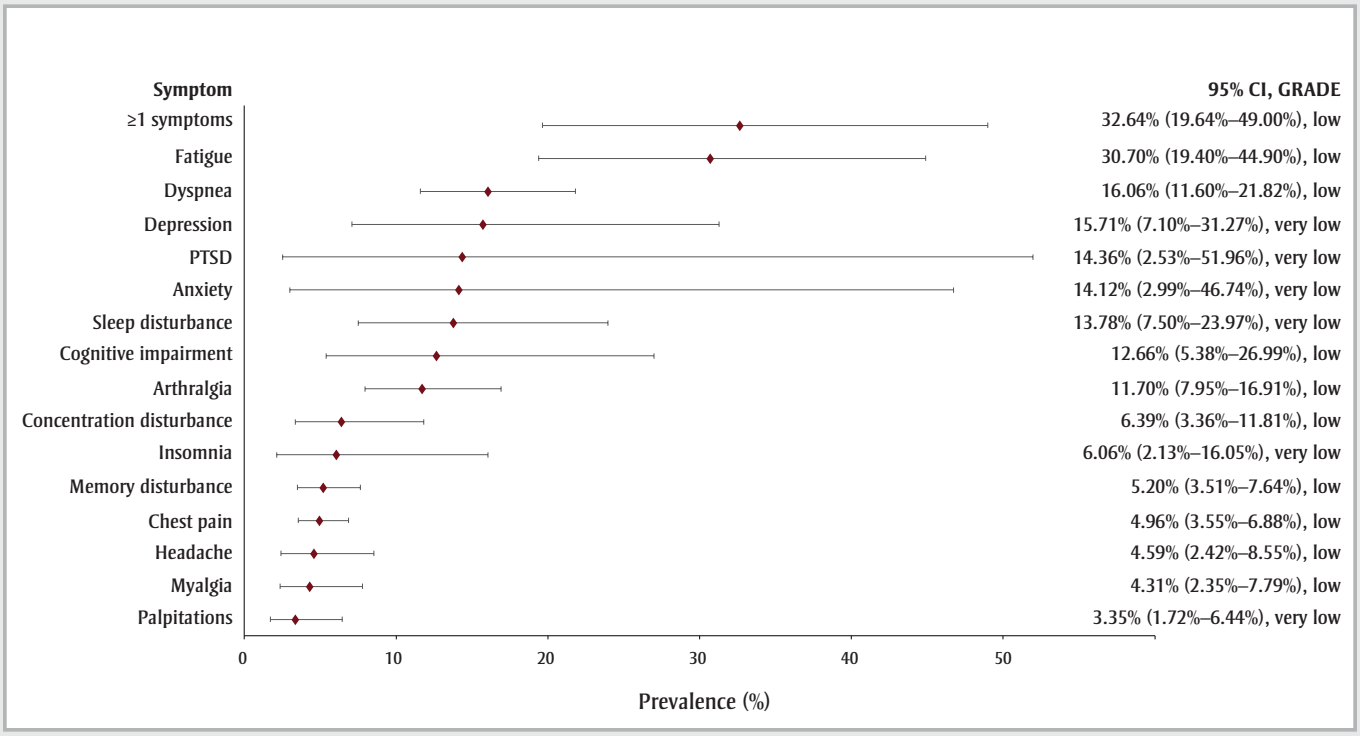
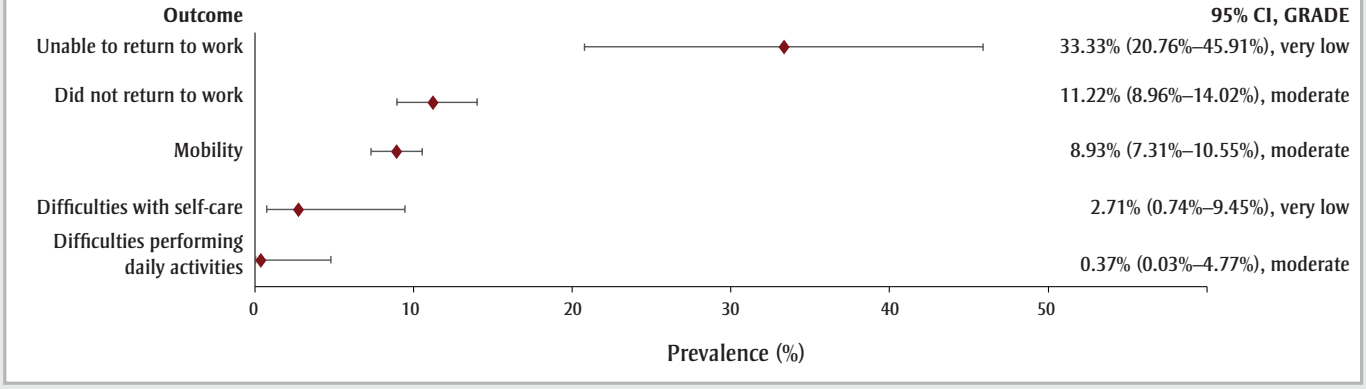


FIGURE 4B
Pooled prevalence estimates of PCC outcomes at 40–52 weeks after confirmed COVID-19



Abbreviations: CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Development, and Evaluations; PCC, post-COVID-19 condition; PTSD, posttraumatic stress disorder.

Notes: Error bars represent 95% CIs. GRADE certainty of evidence levels are high, moderate, low or very low.

FIGURE 5A
Pooled prevalence estimates of PCC symptoms at more than 1 year after confirmed COVID-19

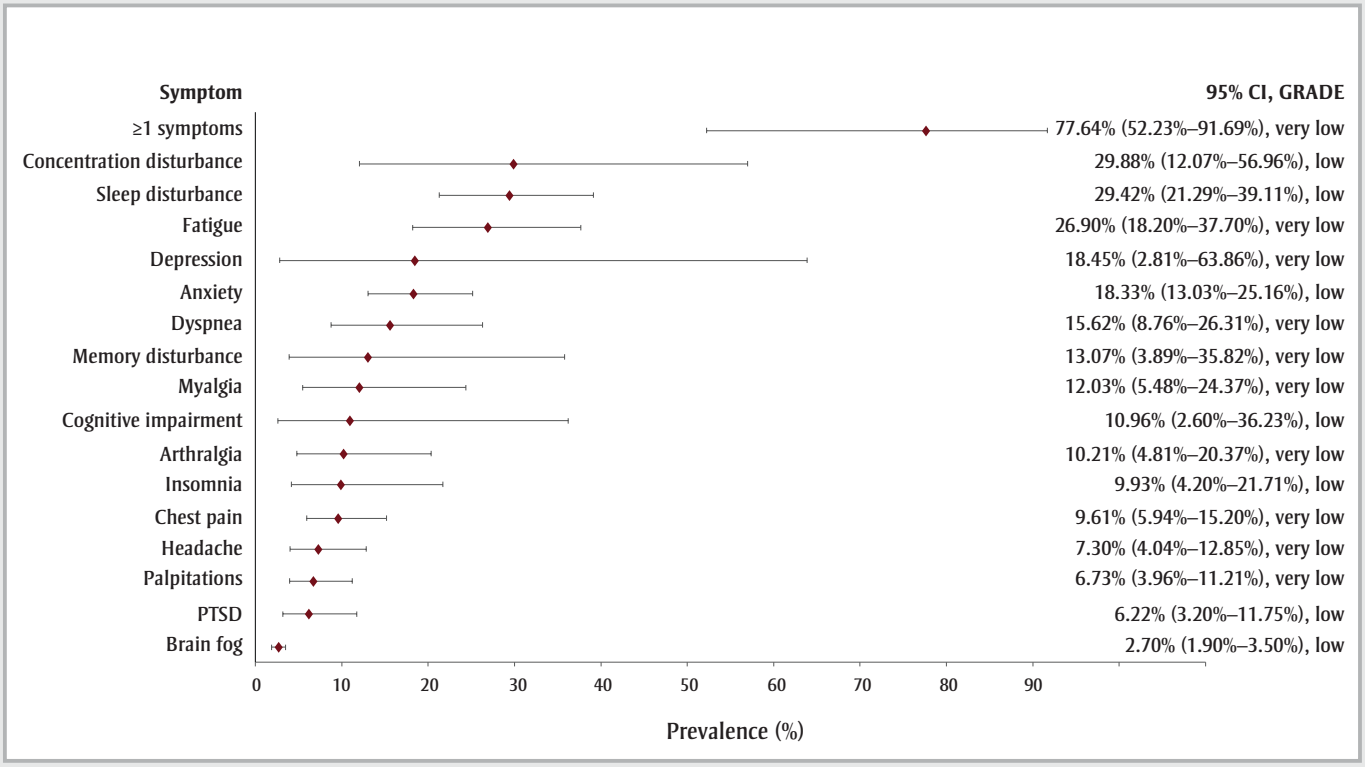
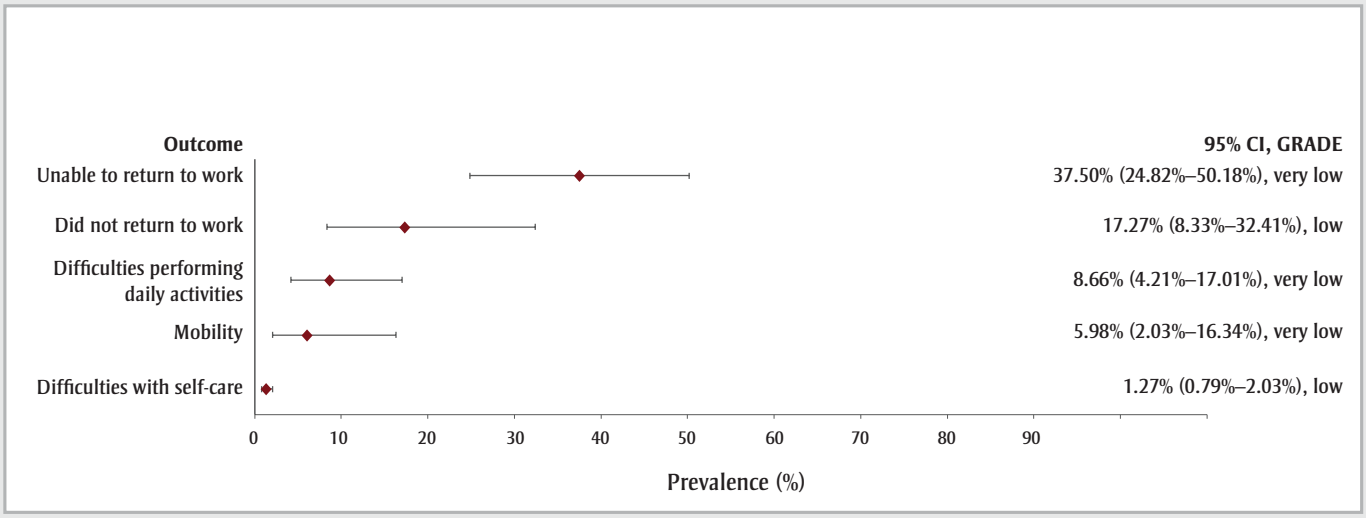


FIGURE 5B
Pooled prevalence estimates of PCC outcomes at more than 1 year after confirmed COVID-19



Abbreviations: CI, confidence interval; GRADE, Grading of Recommendations, Assessment, Development, and Evaluations; PCC, post-COVID-19 condition; PTSD, posttraumatic stress disorder.

Notes: Error bars represent 95% CIs. GRADE certainty of evidence levels are high, moderate, low or very low.

Cycle 1 of the survey included fatigue (72.1%), dyspnea (38.5%) and brain fog (32.9%).[231]

A similar recent US survey found that approximately 14.3% of adults reported experiencing PCC symptoms, with higher prevalence among females and younger individuals.[15] A survey of private households in the United Kingdom found that 2.6% of the total population self-reported PCC symptoms for at least 12 weeks, with 69% continuing to experience the symptoms for a year or longer.[11] An Australian population survey reported that 9.7% of individuals with confirmed or suspected COVID-19 (4.7% of all adults) experienced PCC symptoms.[17]

Our examination of these recent systematic reviews and reports suggests that PCC prevalence ranged between 2.5% and 63.9%.[10,12,16,232-244] This wide range can be attributed to several factors including, but not limited to, the pooling of confirmed and suspected cases, the combination of various study types (prospective and retrospective studies including cross-sectional studies, case reports and case series) and the sampling approach (hospitalized, community-based patients or both).

Other factors include inconsistencies in the definition of PCC, the pooling of studies with different follow-up durations and the diverse methods used to assess symptoms and outcomes with varying degrees of validity. In addition, the variability in demographic characteristics of the participants included in population surveys may have also contributed to this wide variation in prevalence estimates.

The most frequently reported symptoms identified through our extended search were dyspnea (5.4%–80.6%)[12,233-235,237,242,244-248] and fatigue (9.3%–54.2%)[12,233-237,242,244-250]. Others, in order of frequency, were disturbance in health-related quality of life (1.0%–52.0%),[12,235,244,247,248] sleep disturbance (3.5%–47.4%)[12,233-235,237,239,242,244,245,249,251,252] and pain (1.0%–34.5%).[12,233-236,245,247,248,250] The collective prevalence of anxiety, depression and PTSD ranged from 2.0% to 32.0%[12,233-237,239,242,244,245,248,250,252]; of functional impairment from 4.0% to 36.0%[12,235,244,247]; of cognitive impairment from 13.5% to 30%[12,248,249]; of brain fog from 25.5% to 36.0%[242,248,250]; of concentration disturbance from 8.0% to 29%[12,233-235,239,244,245,248]; and of palpitations from 1.0% to 23.0%[12,233-236,239,242,244,245,248]. These findings, derived from reports and systematic reviews included in the extended search, align with our primary findings, particularly regarding the higher prevalence of PCC symptoms among females and among individuals with a history of hospitalization or ICU admission during their initial infection. Data from a 2024 National Academies report[228] were also in line with our findings, as were the findings in the systematic reviews[12,232-239,242,245-252] and authoritative reports[10,231,240-244] identified in our extended search.

Strengths and limitations

This is the first systematic review of evidence that focuses exclusively on prospective studies. We opted to focus on these higher-quality studies to strengthen the reliability of our findings, even if doing so meant foregoing valuable insights from retrospective evidence.

The review summarizes the published evidence on PCC prevalence from various population groups and health care systems over follow-up periods of up to 2 years. The extended search differentiates it from previous reviews that focused on the earlier stages of the condition.

Restricting the study search to English or French language publications (due to time and resources constraints) is a potential limitation. However, we anticipate minimal impact on the overall yield of the search based on prior evidence that language restrictions in systematic reviews often have minimal impact on the overall yield of high-quality evidence, particularly in fields where the majority of relevant and high-quality studies are published in English or French and indexed in the databases we used.[253]

We used a version of the GRADE approach, modified in cooperation with GRADE experts, to better fit the current review when evaluating the COE and assessing the level of confidence in the reported findings. Although this modified version has not yet been validated, it has been adopted for use in other studies (e.g. Righy et al.[33]). GRADE was originally designed for studies of therapeutic interventions, and it continues to present challenges when applied to studies of nontherapeutic exposures or prognostic factors[254] and for prevalence studies. Compared to randomized controlled trials, observational studies are often more heterogenous because of variations in study design, population and sampling as well as nonstandardized outcome assessments. This inherent variability frequently leads to a downgrading of level of evidence certainty, as in our review, where high heterogeneity occurred in nearly 61% of the analyses.

In this review, we did not examine PCC prevalence in undiagnosed individuals or those with suspected but unconfirmed COVID-19. A critical consideration in interpreting PCC prevalence estimates is the type of population included in these studies. Population-based studies that focus solely on PCR-confirmed infections typically report higher prevalence rates (20%–25%), reflecting symptomatic and more severe cases.[232,255] In contrast, studies that incorporate all cases, even asymptomatic cases identified through serological surveys, generally present lower prevalence rates (5%–10%).[232,255] This discrepancy highlights the selective nature of PCR testing during high-demand periods, which predominantly captured symptomatic infections. The current review primarily included prospective studies with confirmed infections, and we acknowledge that this approach might not fully capture PCC prevalence, particularly among asymptomatic or undiagnosed cases.

The differences between our findings and those of population surveys identified in our extended search, such as the CCAHS, likely arise from variances in respondent characteristics, inclusion of both confirmed and suspected cases, and the subjective nature of outcome assessment. These population surveys, although widely used, are prone to sampling bias, self-reporting bias, nonresponse bias and other limitations that can influence prevalence estimates. Furthermore, the temporal relationship between COVID-19 and the reported PCC symptoms may not always be clear, adding to the variability in prevalence data. By comparing our results with these surveys, we aim to highlight how methodological differences and biases in population surveys can account for the observed variations in prevalence estimates.

Our review primarily focused on assessing the global prevalence of PCC to inform clinicians and policy makers. Accordingly, we did not explore any influence of COVID-19 vaccines or the different SARS-CoV-2 variants on PCC prevalence. Expanding

the analysis to include such variables would have significantly increased the scope and complexity, exceeding our resources. Also, the lack of consistent reporting on vaccination and voice-of-the-customer (VOC) data across studies would have introduced potential inaccuracies and inconsistencies if inferred from external sources.

Our pooled prevalence estimates were derived from diverse patient cohorts across various follow-up periods, rather than a single continuously monitored cohort. Therefore, it is essential to carefully evaluate the presented synthesis of evidence while taking into account its strengths and limitations.

Suggestions for future research

The current review highlights the importance of examining PCC prevalence based on major risk factors; and on standardizing outcome assessment methods and case management protocols. Moreover, we encourage prioritizing investigations into equity-deserving populations because certain population groups experienced and continue to experience more pronounced PCC effects.

Conclusion

This review contributes to our collective understanding of the global burden of PCC. Many COVID-19 survivors continue to experience symptoms and functional impairments more than a year after their initial infection. The most commonly reported symptoms include fatigue and dyspnea, which aligns with other published reviews and reports. As emphasized in an earlier version of this systematic review,[256] these results are intended to amplify patient voices, aid researchers and clinicians, and guide policy makers and decision makers in the development of mitigation strategies and support services for COVID-19 survivors living with PCC and their caregivers.

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Conflicts of interest

None to declare.

Authors' contributions and statement

MKT: Data curation, formal analysis, investigation, project administration, supervision, visualization, writing – original draft, writing – review and editing.

TS: Data curation, investigation, validation, visualization, writing – original draft.

AB: Data curation, investigation, writing – original draft.

KM: Conceptualization, data curation, investigation, validation, writing – review and editing.

FRD: Conceptualization, data curation, investigation, validation, writing – review and editing.

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All the authors conducted a thorough review of the manuscript, provided feedback and approved the final manuscript. All authors had access to the study data.

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References

1. World Health Organization. Disease outbreak news: Pneumonia of unknown cause – China [Internet]. Geneva (CH): WHO; 2020 Jan 05 [cited 2024 May 05]. Available from: https://www.who.int/emergencies/disease-outbreak-news/item/2020-DON229

2. World Health Organization. WHO COVID-19 dashboard [Internet]. Geneva (CH): WHO; [cited 2024 Oct 18]. Available from: https://covid19.who.int/

3. Soriano J, Murthy S, Marshall J, Relan P, Diaz J, WHO Clinical Case Definition Working Group on Post-COVID-19 Condition. A clinical case definition of post-COVID-19 condition by a Delphi consensus. Lancet Infect Dis. 2022; 22(4):e102-7. https://doi.org/10.1016/S1473-3099(21)00703-9

4. World Health Organization. A clinical case definition of post COVID-19 condition by a Delphi consensus [Internet]. Geneva (CH): WHO; 2021 Oct 06 [cited 2024 May 05]. Available from: https://iris.who.int/bitstream/handle/10665/345824/WHO-2019-nCoV-Post-COVID-19-condition-Clinical-case-definition-2021.1-eng.pdf?sequence=1

5. World Health Organization. A clinical case definition for post COVID-19 condition in children and adolescents by expert consensus [Internet]. Geneva (CH): WHO; 2023 Feb 16 [cited 2024 May 05]. Available from: https://iris.who.int/bitstream/handle/10665/366126/WHO-2019-nCoV-Post-COVID-19-condition-CA-Clinical-case-definition-2023.1-eng.pdf?sequence=1

6. Stephenson T, Allin B, Nugawela MD, Rojas N, Dalrymple E, Pinto Pereira S, et al. Long COVID (post-COVID-19 condition) in children: a modified Delphi process. Arch Dis Child. 2022;107(7):674-80. https://doi.org/10.1136/archdischild-2021-323624

7. Mirin AA. A preliminary estimate of the economic impact of long COVID in the United States. Fatigue. 2022;10(4):190-9. https://doi.org/10.1080/21641846.2022.2124064

8. Shanbehzadeh S, Tavahomi M, Zanjari N, Ebrahimi-Takamjani I, Amiri-Arimi S. Physical and mental health complications post-COVID-19: scoping review. J Psychosom Res. 2021;147:110525. https://doi.org/10.1016/j.jpsychores.2021.110525

9. Fernández-de-Las-Peñas C, Palacios-Ceña D, Gómez-Mayordomo V, Florencio LL, Cuadrado ML, Plaza-Manzano G, et al. Prevalence of post-COVID-19 symptoms in hospitalized and non-hospitalized COVID-19 survivors: a systematic review and meta-analysis. Eur J Intern Med. 2021;92:55-70. https://doi.org/10.1016/j.ejim.2021.06.009

10. Bull-Otterson L, Baca S, Saydah S, Boehmer TK, Adjei S, Gray S, et al. Post–COVID conditions among adult COVID-19 survivors aged 18–64 and ≥65 years — United States, March 2020–November 2021. MMWR Morb Mortal Wkly Rep. 2022(71):713-17. https://doi.org/10.15585/mmwr.mm7121e1external

11. Office for National Statistics. Prevalence of ongoing symptoms following coronavirus (COVID-19) infection in the UK: 30 March 2023 [Internet]. Newport (UK): Office for National Statistics; 2023 Mar 30 [cited 2024 May 05]. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/bulletins/prevalenceofongoingsymptomsfollowingcoronaviruscovid19infectionintheuk/latest

12. Di Gennaro F, Belati A, Tulone O, Diella L, Fiore Bavaro D, Bonica R, et al. Incidence of long COVID-19 in people with previous SARS-Cov2 infection: a systematic review and meta-analysis of 120,970 patients. Intern Emerg Med. 2022;18(5):1573-81. https://doi.org/10.1007/s11739-022-03164-w

13. Wulf Hanson S, Abbafati C, Aerts JG, Al-Aly Z, Ashbaugh C, Ballouz T, et al. Estimated global proportions of individuals with persistent fatigue, cognitive, and respiratory symptom clusters following symptomatic COVID-19 in 2020 and 2021. JAMA. 2022;328(16):1604-15. https://doi.org/10.1001/jama.2022.18931

14. World Health Organization. Post COVID-19 conditions [Internet]. Geneva (CH): WHO; [cited 2024 May 05]. Available from: https://www.who.int/teams/health-care-readiness/post-covid-19-condition

15. National Center for Health Statistics. Long COVID: Household Pulse Survey [Internet]. Suitland (MD): United States Census Bureau; 2022-2023 [reviewed 2024 Oct 03; cited 2024 May 05]. Available from: https://www.cdc.gov/nchs/covid19/pulse/long-covid.htm

16. Statistics Canada. Experiences of Canadians with long-term symptoms following COVID-19 [Internet]. Ottawa (ON): Statistics Canada; 2023 Dec 08 [cited 2024 May 05]. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/231208/dq231208a-eng.htm?HPA=1

17. Biddle N, Korda R. The experience of COVID-19 in Australia, including long-COVID—Evidence from the COVID-19 Impact Monitoring Survey Series, August 2022 [Internet]. Canberra (AU): ANU Centre for Social Research and Methods, National Centre for Epidemiology and Population Health; 2022 Oct 12 [cited 2024 May 05]. Available from: https://csrm.cass.anu.edu.au/sites/default/files/docs/2022/10/The_experience_of_COVID-19_in_Australia_-_For_web.pdf

18. Statistics Canada. Long term COVID-19 symptoms among Canadian adults who self-reported a prior positive test or suspected SARS-CoV-2 infection, by sex and age group [Internet]. Ottawa (ON): Statistics Canada; 2023 Aug 03 [cited 2024 Oct 17]. Available from: https://doi.org/10.25318/1310086701-eng

19. Rafferty E, Unsal A, Kirwin E. Healthcare costs and effects of post-COVID-19 condition in Canada. Can Commun Dis Rep. 2023;49(10):425-32. https://doi.org/10.14745/ccdr.v49i10a03

20. Higgins JP, Green S, editors. Cochrane handbook for systematic reviews of interventions, version 5.0.0. London (UK): Cochrane; 2008. https://doi.org/10.1002/9780470712184

21. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. Updating guidance for reporting systematic reviews: development of the PRISMA 2020 statement. J Clin Epidemiol. 2021;134:103-12. https://doi.org/10.1016/j.jclinepi.2021.02.003

22. Sackett DL. Rules of evidence and clinical recommendations on the use of antithrombotic agents. Chest. 1989;95(2 Suppl):2S-4S. https://doi.org/10.1378/chest.89.2_Supplement.2S

23. Howick J, Chalmers I, Glasziou P, Greenhalgh T, Heneghan C, Liberati A, et al. OCEBM levels of evidence [Internet]. Oxford (UK): Centre for Evidence-Based Medicine; 2011 [cited 2024 May 05]. Available from: https://www.cebm.ox.ac.uk/resources/levels-of-evidence/ocebm-levels-of-evidence

24. Burns PB, Rohrich RJ, Chung KC. The levels of evidence and their role in evidence-based medicine. Plast Reconstr Surg. 2011;128(1):305-10. https://doi.org/10.1097/PRS.0b013e318219c171

25. Venkatesan P. NICE guideline on long COVID. Lancet Respir Med. 2021;9(2):129. https://doi.org/10.1016/S2213-2600(21)00031-X

26. Evidence Partners. DistillerSR [software]. 2008. Available from: https://www.distillersr.com/products/distillersr-systematic-review-software

27. Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Chapter 5: Systematic reviews of prevalence and incidence. In: Aromataris E, Munn Z, editors. JBI reviewer's manual for evidence synthesis. Adelaide (AU): The Joanna Briggs Institute; 2020. pp. 176-217. https://doi.org/10.46658/JBIRM-17-05

28. The Joanna Briggs Institute. The Joanna Briggs Institute critical appraisal tools for use in JBI systematic reviews: Checklist for prevalence studies [Internet]. Adelaide (AU): Joanna Briggs Institute, University of Adelaide; 2017 [cited 2024 May 05]. Available from: https://jbi.global/sites/default/files/2019-05/JBI_Critical_Appraisal-Checklist_for_Prevalence_Studies2017_0.pdf

29. Microsoft Corporation. Microsoft Excel [software]. 2019. Available from: https://office.microsoft.com/excel

30. R Foundation for Statistical Computing. RStudio 1.4.1106 [software]. 2021. Available from: https://www.npackd.org/p/rstudio/1.4.1106

31. Balshem H, Helfand M, Schünemann HJ, Oxman AD, Kunz R, Brozek J, et al. GRADE guidelines: 3. Rating the quality of evidence. J Clin Epidemiol. 2011;64(4):401-6. https://doi.org/10.1016/j.jclinepi.2010.07.015

32. Iorio A, Spencer FA, Falavigna M, Alba C, Lang E, Burnand B, et al. Use of GRADE for assessment of evidence about prognosis: rating confidence in estimates of event rates in broad categories of patients. BMJ. 2015;350:h870. https://doi.org/10.1136/bmj.h870

33. Righy C, Rosa RG, da Silva RT, Kochhann R, Migliavaca CB, Robinson CC, et al. Prevalence of post-traumatic stress disorder symptoms in adult critical care survivors: a systematic review and meta-analysis. Crit Care. 2019;23(1):213. https://doi.org/10.1186/s13054-019-2489-3

34. Li J, Xia W, Zhan C, Liu S, Yin Z, Wang J, et al. A telerehabilitation programme in post-discharge COVID-19 patients (TERECO): a randomised controlled trial. Thorax. 2022;77(7):697-706. https://doi.org/10.1136/thoraxjnl-2021-217382

35. Vlake JH, van Bommel J, Wils EJ, Joe Bienvenu J, Merel E Hellemons ME, Korevaar TI, et al. Intensive care unit-specific virtual reality for critically ill patients with COVID-19: multicenter randomized controlled trial. J Med Internet Res. 2022;24(1):e32368. https://doi.org/10.2196/32368

36. Anastasio F, Barbuto S, Scarnecchia E, et al. Medium-term impact of COVID-19 on pulmonary function, functional capacity and quality of life. Eur Respir J. 2021;58(3):2004015. https://doi.org/10.1183/13993003.04015-2020

37. Bellan M, Soddu D, Balbo PE, Baricich A, Zeppegno P, Avanzi GC, et al. Respiratory and psychophysical sequelae among patients with COVID-19 four months after hospital discharge. JAMA Netw Open. 2021;4(1):e2036142. https://doi.org/10.1001/jamanetworkopen.2020.36142

38. Bellan M, Baricich A, Patrucco F, Zeppegno P, Gramaglia C, Balbo PE, et al. Long-term sequelae are highly prevalent one year after hospitalization for severe COVID-19. Sci Rep. 2021;11(1):22666. https://doi.org/10.1038/s41598-021-01215-4

39. Boglione L, Meli G, Poletti F, Rostagno R, Moglia R, Cantone M, et al. Risk factors and incidence of long-COVID syndrome in hospitalized patients: does remdesivir have a protective effect? QJM. 2021;114(12):865-71. https://doi.org/10.1093/qjmed/hcab297

40. Boscolo-Rizzo P, Guida F, Polesel J, Marcuzzo AV, Capriotti V, D'Alessandro A, et al. Sequelae in adults at 12 months after mild-to-moderate coronavirus disease 2019 (COVID-19). Int Forum Allergy Rhinol. 2021;11(12):1685-8. https://doi.org/https://doi.org/10.1002/alr.22832

41. Bozzetti S, Ferrari S, Zanzoni S, Alberti D, Braggio M, Carta S, et al. Neurological symptoms and axonal damage in COVID-19 survivors: are there sequelae? Immunol Res. 2021;69(6):553-7. https://doi.org/10.1007/s12026-021-09220-5

42. Caruso D, Guido G, Zerunian M, Polidori T, Lucertini E, Pucciarelli F, et al. Post-acute sequelae of COVID-19 pneumonia: six-month chest CT follow-up. Radiology. 2021;301(2):E396-405. https://doi.org/10.1148/radiol.2021210834

43. Clavario P, De Marzo V, Lotti R, Barbara C, Porcile A, Russo C, et al. Cardiopulmonary exercise testing in COVID-19 patients at 3 months follow-up. Int J Cardiol. 2021;340:113-8. https://doi.org/10.1016/j.ijcard.2021.07.033

44. Comelli A, Viero G, Bettini G, Nobili A, Tettamanti M, Galbussera AA, et al. Patient-reported symptoms and sequelae 12 months after COVID-19 in hospitalized adults: a multicenter long-term follow-up study. Front Med (Lausanne). 2022;9:834354. https://doi.org/10.3389/fmed.2022.834354

45. Cristillo V, Pilotto A, Cotti Piccinelli S, Bonzi G, Canale A, Gipponi S, et al. Premorbid vulnerability and disease severity impact on Long-COVID cognitive impairment. Aging Clin Exp Res. 2022;34(1):257-60. https://doi.org/10.1007/s40520-021-02042-3

46. De Lorenzo R, Cinel E, Cilla M, Compagnone N, Ferrante M, Falbo E, et al. Physical and psychological sequelae at three months after acute illness in COVID-19 survivors. Panminerva Med. 2023;65(3):312-20. https://doi.org/10.23736/s0031-0808.21.04399-8

47. De Lorenzo R, Palmisano A, Esposito A, Gnasso C, Nicoletti V, Leone R, et al. Myosteatosis significantly predicts persistent dyspnea and mobility problems in COVID-19 survivors. Front Nutr. 2022;9:846901. https://doi.org/10.3389/fnut.2022.846901

48. Faverio P, Luppi F, Rebora P, Busnelli S, Stainer A, Catalano M, et al. Six-month pulmonary impairment after severe covid-19: a prospective, multicentre follow-up study. Respiration. 2021;100(11):1078-87. https://doi.org/10.1159/000518141

49. Faverio P, Luppi F, Rebora P, D'Andrea G, Stainer A, Busnelli S, et al. One-year pulmonary impairment after severe COVID-19: a prospective, multicenter follow-up study. Respir Res. 2022;23(1):65. https://doi.org/10.1186/s12931-022-01994-y

50. Ferioli M, Prediletto I, Bensai S, Betti S, Daniele F, Di Scioscio V, et al. Spontaneous evolution of COVID-19 lung sequelae: results from a double-step follow-up. Respiration. 2022;101(4):381-93. https://doi.org/10.1159/000521316

51. Gramaglia C, Gambaro E, Bellan M, Balbo PE, Baricich A, Sainaghi PP, et al. Mid-term psychiatric outcomes of patients recovered from COVID-19 from an Italian cohort of hospitalized patients. Front Psychiatry. 2021;12:667385. https://doi.org/10.3389/fpsyt.2021.667385

52. Latronico N, Peli E, Calza S, Rodella F, Novelli MP, Andrea Cella A, et al. Physical, cognitive and mental health outcomes in 1-year survivors of COVID-19-associated ARDS. Thorax. 2022;77(3):300-3. https://doi.org/10.1136/thoraxjnl-2021-218064

53. Maestrini V, Birtolo LI, Francone M, Galardo G, Galea N, Severino P, et al. Cardiac involvement in consecutive unselected hospitalized COVID-19 population: in-hospital evaluation and one-year follow-up. Int J Cardiol. 2021;339:235-42. https://doi.org/10.1016/j.ijcard.2021.06.056

54. Martino GP, Benfaremo D, Bitti G, Valeri G, Postacchini L, Marchetti A, et al. 6 and 12 month outcomes in patients following COVID-19-related hospitalization: a prospective monocentric study. Intern Emerg Med. 2022;17(6):1641-9. https://doi.org/10.1007/s11739-022-02979-x

55. Mattioli F, Stampatori C, Righetti F, Sala E, Tomasi C, De Palma G. Neurological and cognitive sequelae of Covid-19: a four month follow-up. J Neurol. 2021;268(12):4422-8. https://doi.org/10.1007/s00415-021-10579-6

56. Mazza MG, Palladini M, De Lorenzo R, Magnaghi C, Poletti S, Furlan R, et al. Persistent psychopathology and neurocognitive impairment in COVID-19 survivors: effect of inflammatory biomarkers at three-month follow-up. Brain Behav Immun. 2021;94:138-47. https://doi.org/10.1016/j.bbi.2021.02.021

57. Mazza MG, Palladini M, De Lorenzo R, Bravi B, Poletti S, Furlan R, et al. One-year mental health outcomes in a cohort of COVID-19 survivors. J Psychiatr Res. 2022;145:118-24. https://doi.org/10.1016/j.jpsychires.2021.11.031

58. Noviello D, Costantino A, Muscatello A, Bandera A, Consonni D, Vecchi M, et al. Functional gastrointestinal and somatoform symptoms five months after SARS-CoV-2 infection: a controlled cohort study. Neurogastroenterol Motil. 2021;34(2):e14187. https://doi.org/10.1111/nmo.14187

59. Peghin M, Palese A, Venturini M, De Martino M, Gerussi V, Graziano E, et al. Post-COVID-19 symptoms 6 months after acute infection among hospitalized and non-hospitalized patients. Clin Microbiol Infect. 2021;27(10):1507-13. https://doi.org/10.1016/j.cmi.2021.05.033

60. Poletti S, Palladini M, Mazza MG, De Lorenzo R, Furlan R, Ciceri F, et al. Long-term consequences of COVID-19 on cognitive functioning up to 6 months after discharge: role of depression and impact on quality of life. Eur Arch Psychiatry Clin Neurosci. 2022;272(5):773-82. https://doi.org/10.1007/s00406-021-01346-9

61. Righi E, Mirandola M, Mazzaferri F, Razzaboni E, Zaffagnini A, Erbogasto A, et al. Long-term patient-centred follow-up in a prospective cohort of patients with COVID-19. Infect Dis Ther. 2021;10(3):1579-90. https://doi.org/10.1007/s40121-021-00461-3

62. Righi E, Mirandola M, Mazzaferri F, Dossi G, Razzaboni E, Zaffagnini A, et al. Determinants of persistence of symptoms and impact on physical and mental wellbeing in Long COVID: a prospective cohort study. J Inf. 2022;84(4):566-72. https://doi.org/10.1016/j.jinf.2022.02.003

63. Rigoni M, Torri E, Nollo G, Donne LD, Rizzardo S, Lenzi L, et al. "Long COVID" results after hospitalization for SARS-CoV-2 infection. Sci Rep. 2022;12(1):9581. https://doi.org/10.1038/s41598-022-13077-5

64. Straudi S, Manfredini F, Baroni A, Milani G, Fregna G, Schincaglia N, et al. Construct validity and responsiveness of the COVID-19 Yorkshire Rehabilitation Scale (C19-YRS) in a cohort of Italian hospitalized COVID-19 patients. Int J Environ Res Public Health. 2022;19(11):6696. https://doi.org/10.3390/ijerph19116696

65. Zangrillo A, Belletti A, Palumbo D, Calvi MR, Guzzo F, Fominskiy EV, et al. One-year multidisciplinary follow-up of patients with COVID-19 requiring invasive mechanical ventilation. J Cardiothorac Vasc Anesth. 2022;36(5):1354-63. https://doi.org/10.1053/j.jvca.2021.11.032

66. Cao J, Zheng X, Wei W, Chu X, Chen X, Wang Y, et al. Three-month outcomes of recovered COVID-19 patients: prospective observational study. Ther Adv Respir Dis. 2021;15:17534666211009410. https://doi.org/10.1177/17534666211009410

67. Chai C, Feng X, Lu M, Li S, Chen K, Wang H, et al. One-year mortality and consequences of COVID-19 in cancer patients: a cohort study. IUBMB Life. 2021;73(10):1244-56. https://doi.org/10.1002/iub.2536

68. Chai C, Chen K, Li S, Cheng G, Wang W, Wang H, et al. Effect of elevated fasting blood glucose level on the 1-year mortality and sequelae in hospitalized COVID-19 patients: a bidirectional cohort study. J Med Virol. 2022;94(7):3240-50. https://doi.org/10.1002/jmv.27737

69. Chen Y, Zhang X, Zeng X, Xu T, Xiao W, Yang X, et al. Prevalence and risk factors for postinfectious cough in discharged patients with coronavirus disease 2019 (COVID-19). J Thorac Dis. 2022;14(6):2079-88. https://doi.org/10.21037/jtd-21-876

70. Cui D, Wang Y, Huang L, Gu X, Huang Z, Mu S, et al. Rheumatic symptoms following coronavirus disease 2019 (COVID-19): a chronic post-COVID-19 condition. Open Forum Infect Dis. 2022;9(6):ofac170. https://doi.org/10.1093/ofid/ofac170

71. Fang X, Ming C, Cen Y, Lin H, Zhan K, Yang S, et al. Post-sequelae one year after hospital discharge among older COVID-19 patients: a multicenter prospective cohort study. J Infect. 2022;84(2):179-86. https://doi.org/10.1016/j.jinf.2021.12.005

72. Han X, Fan Y, Alwalid O, Li N, Jia X, Yuan M, et al. Six-month follow-up chest CT findings after severe COVID-19 pneumonia. Radiology. 2021;299(1):E177-86. https://doi.org/10.1148/radiol.2021203153

73. Huang L, Yao Q, Gu X, Wang Q, Ren L, Wang Y, et al. 1-year outcomes in hospital survivors with COVID-19: a longitudinal cohort study. Lancet. 2021;398(10302):747-58. https://doi.org/10.1016/s0140-6736(21)01755-4

74. Huang L, Li X, Gu X, Zhang H, Ren L, Guo L, et al. Health outcomes in people 2 years after surviving hospitalisation with COVID-19: a longitudinal cohort study. Lancet Respir Med. 2022;10(9):863-76. https://doi.org/10.1016/s2213-2600(22)00126-6

75. Huang X, Liu L, Eli B, Wang J, Chen Y, Liu Z. Mental health of COVID-19 survivors at 6 and 12 months postdiagnosis: a cohort study. Front Psychiatry. 2022;13:863698. https://doi.org/10.3389/fpsyt.2022.863698

76. Lauria A, Carfì A, Benvenuto F, Bramato G, Ciciarello F, Rocchi S, et al. Neuropsychological measures of Long COVID-19 fog in older subjects. Clin Geriatr Med. 2022;38(3):593-603. https://doi.org/10.1016/j.cger.2022.05.003

77. Li X, Shen C, Wang L, Majumder S, Zhang D, Deen MJ, et al. Pulmonary fibrosis and its related factors in discharged patients with new corona virus pneumonia: a cohort study. Respir Res. 2021;22(1):203. https://doi.org/10.1186/s12931-021-01798-6

78. Li Y, Wang X, Shen XR, Geng R, Xie N, Han JF, et al. A 1-year longitudinal study on COVID-19 convalescents reveals persistence of anti-SARS-CoV-2 humoral and cellular immunity. Emerg Microbes Infect. 2022;11(1):902-13. https://doi.org/10.1080/22221751.2022.2049984

79. Liang L, Yang B, Jiang N, Fu W, He X, Zhou Y, et al. Three-month follow-up study of survivors of coronavirus disease 2019 after discharge. J Korean Med Sci. 2020;35(47):e418. https://doi.org/10.3346/jkms.2020.35.e418

80. Liu Q, Mak JWY, Su Q, Yeoh YK, Lui GC, Ng SS, et al. Gut microbiota dynamics in a prospective cohort of patients with post-acute COVID-19 syndrome. Gut. 2022;71(3):544-52. https://doi.org/10.1136/gutjnl-2021-325989

81. Liu T, Wu D, Yan W, Wang X, Zhang X, Ma K, et al. Twelve-month systemic consequences of coronavirus disease 2019 (COVID-19) in patients discharged from hospital: a prospective cohort study in Wuhan, China. Clin Infect Dis. 2022;74(11):1953-65. https://doi.org/10.1093/cid/ciab703

82. Liu YH, Chen Y, Wang QH, et al. One-year trajectory of cognitive changes in older survivors of COVID-19 in Wuhan, China: a longitudinal cohort study. JAMA Neurol. 2022;79(5):509-17. https://doi.org/10.1001/jamaneurol.2022.0461

83. Shang YF, Liu T, Yu JN, Xu XR, Zahid KR, Wei YC, et al. Half-year follow-up of patients recovering from severe COVID-19: analysis of symptoms and their risk factors. J Intern Med. 2021;290(2):444-50. https://doi.org/10.1111/joim.13284

84. Sun LL, Wang J, Wang YS, Pan X, Luo J, Liu H, et al. 15-Month health outcomes and the related risk factors of hospitalized COVID-19 patients from onset: a cohort study. Front Med (Lausanne). 2022;9:854788. https://doi.org/10.3389/fmed.2022.854788

85. Wu Q, Hou X, Li H, Guo J, Li Y, Yang F, et al. A follow-up study of respiratory and physical function after discharge in patients with redetectable positive SARS-CoV-2 nucleic acid results following recovery from COVID-19. Int J Infect Dis. 2021;107:5-11. https://doi.org/10.1016/j.ijid.2021.04.020

86. Wu X, Liu X, Zhou Y, Yu H, Li R, Zhan Q, et al. 3-month, 6-month, 9-month, and 12-month respiratory outcomes in patients following COVID-19-related hospitalisation: a prospective study. Lancet Respir Med. 2021;9(7):747-54. https://doi.org/10.1016/s2213-2600(21)00174-0

87. Xiong L, Li Q, Cao X, Xiong H, Huang M, Yang F, et al. Dynamic changes of functional fitness, antibodies to SARS-CoV-2 and immunological indicators within 1 year after discharge in Chinese health care workers with severe COVID-19: a cohort study. BMC Med. 2021;19(1):163. https://doi.org/10.1186/s12916-021-02042-0

88. Zhan K, Zhang X, Wang B, Jiang Z, Fang X, Yang S, et al. Short- and long-term prognosis of glycemic control in COVID-19 patients with type 2 diabetes. QJM. 2022;115(3):131-9. https://doi.org/10.1093/qjmed/hcac020

89. Zhang J, Shu T, Zhu R, Yang F, Zhang B, Lai X. The long-term effect of COVID-19 disease severity on risk of diabetes incidence and the near 1-year follow-up outcomes among postdischarge patients in Wuhan. J Clin Med. 2022;11(11):3094. https://doi.org/10.3390/jcm11113094

90. Zhou F, Tao M, Shang L, Liu Y, Pan G, Jin Y, et al. Assessment of sequelae of COVID-19 nearly 1 year after diagnosis. Front Med (Lausanne). 2021;8:717194. https://doi.org/10.3389/fmed.2021.717194

91. Aranda J, Oriol I, Martín M, Feria L, Vázquez N, Rhyman N, et al. Long-term impact of COVID-19 associated acute respiratory distress syndrome. J Infect. 2021;83(5):581-8. https://doi.org/10.1016/j.jinf.2021.08.018

92. Benítez ID, Moncusí-Moix A, Vaca R, Gort-Paniello C, Minguez O, Santisteve S, et al. Sleep and circadian health of critical COVID-19 survivors 3 months after hospital discharge. Crit Care Med. 2022;50(6):945-54. https://doi.org/10.1097/ccm.0000000000005476

93. Benítez ID, de Batlle J, Torres G, González J, de Gonzalo-Calvo D, Targa AD, et al. Prognostic implications of comorbidity patterns in critically ill COVID-19 patients: a multicenter, observational study. Lancet Reg Health Eur. 2022;18:100422. https://doi.org/10.1186/s12931-022-01994-y

94. Carrillo-Garcia P, Garmendia-Prieto B, Cristofori G, Montoya IL, Hidalgo JJ, Feijoo MQ, et al. Health status in survivors older than 70 years after hospitalization with COVID-19: observational follow-up study at 3 months. Eur Geriatr Med. 2021;12(5):1091-4. https://doi.org/10.1007/s41999-021-00516-1

95. Carrillo-Garcia P, Garmendia-Prieto B, Cristofori G, Lozano-Montoya I, Gómez-Pavón J. Health impact on the elderly survivors of COVID-19: six months follow up. Rev Esp Geriatr Gerontol. 2022;57(3):146-9. https://doi.org/10.1016/j.regg.2022.03.004

96. Domènech-Montoliu S, Puig-Barberà J, Pac-Sa MR, et al. ABO blood groups and the incidence of complications in COVID-19 patients: A population-based prospective cohort study. Int J Environ Res Public Health. 2021;18(19):10039. https://doi.org/10.3390/ijerph181910039

97. Fernández-de-las-Peñas C, Guijarro C, Plaza-Canteli S, Hernández-Barrera V, Torres-Macho J. Prevalence of post-COVID-19 cough one year after SARS-CoV-2 infection: a multicenter study. Lung. 2021;199(3):249-53. https://doi.org/10.1007/s00408-021-00450-w

98. Fernández-de-Las-Peñas C, Ryan-Murua P, Rodríguez-Jiménez J, Palacios-Ceña M, Arendt-Nielsen L, Torres-Macho J. Serological biomarkers at hospital admission are not related to long-term post-COVID fatigue and dyspnea in COVID-19 survivors. Respiration. 2022;101(7):658-65. https://doi.org/10.1159/000524042

99. Fernández-de-Las-Peñas C, Martín-Guerrero JD, Florencio LL, Navarro-Pardo E, Rodríguez-Jiménez J, Torres-Macho J, et al. Clustering analysis reveals different profiles associating long-term post-COVID symptoms, COVID-19 symptoms at hospital admission and previous medical co-morbidities in previously hospitalized COVID-19 survivors. Infection. 2023;51(1):1-9. https://doi.org/10.1007/s15010-022-01822-x

100. Fernández-de-Las-Peñas C, Martín-Guerrero JD, Cancela-Cilleruelo I, Rodríguez-Jiménez J, Moro-López-Menchero P, Pellicer-Valero OJ. Exploring trajectory recovery curves of post-COVID cognitive symptoms in previously hospitalized COVID-19 survivors: the LONG-COVID-EXP-CM multicenter study. J Neurol. 2022;269(9):4613-7. https://doi.org/10.1007/s00415-022-11176-x

101. García-Abellán J, Padilla S, Fernández-González M, García JA, Agulló V, Andreo M, et al. Antibody response to SARS-CoV-2 is associated with long-term clinical outcome in patients with COVID-19: a longitudinal study. J Clin Immunol. 2021;41(7):1490-501. https://doi.org/10.1007/s10875-021-01083-7

102. González J, Benítez ID, Carmona P, Santisteve S, Monge A, Moncusí-Moix A, et al. Pulmonary function and radiologic features in survivors of critical COVID-19: a 3-month prospective cohort. Chest. 2021;160(1):187-98. https://doi.org/10.1016/j.chest.2021.02.062

103. Guasp M, Muñoz-Sánchez G, Martínez-Hernández E, Santana D, Carbayo Á, Naranjo L, et al. CSF biomarkers in COVID-19 associated encephalopathy and encephalitis predict long-term outcome. Front Immunol. 2022;13:866153. https://doi.org/10.3389/fimmu.2022.866153

104. Izquierdo A, Mojón D, Bardají A, Carrasquer A, Calvo-Fernández A, Carreras-Mora J, et al. Myocardial injury as a prognostic factor in mid- and long-term follow-up of COVID-19 survivors. J Clin Med. 2021;10(24):5900. https://doi.org/10.3390/jcm10245900

105. Maestre-Muñiz MM, Arias Á, Mata-Vázquez E, Martín-Toledano M, López-Larramona G, Ruiz-Chicote AM, et al. Long-term outcomes of patients with coronavirus disease 2019 at one year after hospital discharge. J Clin Med. 2021;10(13):2945. https://doi.org/10.3390/jcm10132945

106. Núñez-Fernández M, Ramos-Hernández C, García-Río F, Torres-Durán M, Nodar-Germiñas A, Tilve-Gómez A, et al. Alterations in respiratory function test three months after hospitalisation for COVID-19 pneumonia: value of determining nitric oxide diffusion. J Clin Med. 2021;10(10):2119. https://doi.org/10.3390/jcm10102119

107. Pérez-González A, Araújo-Ameijeiras A, Fernández-Villar A, Crespo M, Poveda E. Long COVID in hospitalized and non-hospitalized patients in a large cohort in Northwest Spain, a prospective cohort study. Sci Rep. 2022;12(1):3369. https://doi.org/10.1038/s41598-022-07414-x

108. Sibila O, Albacar N, Perea L, Faner R, Torralba Y, Hernandez-Gonzalez F, et al. Lung function sequelae in COVID-19 patients 3 months after hospital discharge. Arch Bronconeumol. 2021;57:59-61. https://doi.org/10.1016/j.arbres.2021.01.036

109. Taboada M, Rodríguez N, Diaz-Vieito M, Domínguez MJ, Casal A, Riveiro V, et al. Quality of life and persistent symptoms after hospitalization for COVID-19. A prospective observational study comparing ICU with non-ICU patients. Rev Esp Anestesiol Reanim (Engl Ed). 2022;69(6):326-35. https://doi.org/10.1016/j.redare.2022.06.002

110. Vargas Centanaro G, Calle Rubio M, Álvarez-Sala Walther JL, Martinez-Sagasti F, Albuja Hidalgo A, Herranz Hernández R, et al. Long-term outcomes and recovery of patients who survived COVID-19: LUNG INJURY COVID-19 Study. Open Forum Infect Dis. 2022;9(4):ofac098. https://doi.org/10.1093/ofid/ofac098

111. Zabana Y, Marín-Jiménez I, Rodríguez-Lago I, Vera I, Martín-Arranz MD, Guerra I, et al. Nationwide COVID-19-EII Study: incidence, environmental risk factors and long-term follow-up of patients with inflammatory bowel disease and COVID-19 of the ENEIDA registry. J Clin Med. 2022;11(2):421. https://doi.org/10.3390/jcm11020421

112. Cortés Zamora EB, Mas Romero M, Tabernero Sahuquillo MT, Avendaño Céspedes A, Andrés-Petrel F, Gómez Ballesteros C, et al. Psychological and functional impact of COVID-19 in long-term care facilities: the COVID-A study. Am J Geriatr Psychiatry. 2022; 30(4):431-43. https://doi.org/10.1016/j.jagp.2022.01.007

113. Chand S, Kapoor S, Naqvi A, Thakkar J, Fazzari MJ, Orsi D, et al. Long-term follow up of renal and other acute organ failure in survivors of critical illness due to Covid-19. J Intensive Care Med. 2022;37(6):736-42. https://doi.org/10.1177/08850666211062582

114. Durstenfeld MS, Peluso MJ, Kelly JD, Win S, Swaminathan S, Li D, et al. Role of antibodies, inflammatory markers, and echocardiographic findings in postacute cardiopulmonary symptoms after SARS-CoV-2 infection. JCI Insight. 2022;7(10):e157053. https://doi.org/10.1172/jci.insight.157053

115. Frontera JA, Yang D, Lewis A, Patel P, Medicherla C, Arena V, et al. A prospective study of long-term outcomes among hospitalized COVID-19 patients with and without neurological complications. J Neurol Sci. 2021;426: 117486. https://doi.org/10.1016/j.jns.2021.117486

116. Frontera JA, Yang D, Medicherla C, Baskharoun S, Bauman K, Bell L, et al. Trajectories of neurologic recovery 12 months after hospitalization for COVID-19: a prospective longitudinal study. Neurology. 2022;99(1):e33-45. https://doi.org/10.1212/wnl.0000000000200356

117. Hentschel CB, Abramoff BA, Dillingham TR, Pezzin LE. Race, ethnicity, and utilization of outpatient rehabilitation for treatment of post COVID-19 condition. PMR. 2022;14(11):1315-24. https://doi.org/10.1002/pmrj.12869

118. Horwitz LI, Garry K, Prete AM, Sharma S, Mendoza F, Kahan T, et al. Six-month outcomes in patients hospitalized with severe COVID-19. J Gen Intern Med. 2021;36(12):3772-7. https://doi.org/10.1007/s11606-021-07032-9

119. Jacobson KB, Rao M, Bonilla H, Subramanian A, Hack I, Madrigal M, et al. Patients with uncomplicated coronavirus disease 2019 (COVID-19) have long-term persistent symptoms and functional impairment similar to patients with severe COVID-19: a cautionary tale during a global pandemic. Clin Infect Dis. 2021;73(3): e826-29. https://doi.org/10.1093/cid/ciab103

120. Jia X, Cao S, Lee AS, Manohar M, Sindher SB, Ahuja N, et al. Anti-nucleocapsid antibody levels and pulmonary comorbid conditions are linked to post-COVID-19 syndrome. JCI Insight. 2022;7(13):e156713. https://doi.org/10.1172/jci.insight.156713

121. McFann K, Baxter BA, LaVergne SM, Stromberg S, Berry K, Tipton M, et al. Quality of life (QoL) is reduced in those with severe COVID-19 disease, post-acute sequelae of COVID-19, and hospitalization in United States adults from northern Colorado. Int J Environ Res Public Health. 2021;18(21):11048. https://doi.org/10.3390/ijerph182111048

122. Peluso MJ, Kelly JD, Lu S, Goldberg SA, Davidson MC, Mathur S, et al. Persistence, magnitude, and patterns of postacute symptoms and quality of life following onset of SARS-CoV-2 infection: cohort description and approaches for measurement. Open Forum Infect Dis. 2022;9(2):ofab640. https://doi.org/10.1093/ofid/ofab640

123. Qin ES, Gold LS, Singh N, Wysham KD, Hough CL, Patel PB, et al. Physical function and fatigue recovery at 6 months after hospitalization for COVID-19. PM R. 2023;15(3):314-24. https://doi.org/10.1002/pmrj.12866

124. Savarraj JP, Burkett AB, Hinds SN, Paz AS, Assing A, Juneja S, et al. Pain and other neurological symptoms are present at 3 months after hospitalization in COVID-19 patients. Front Pain Res (Lausanne). 2021;2:737961. https://doi.org/10.3389/fpain.2021.737961

125. Wang Z, Muecksch F, Schaefer-Babajew D, Finkin S, Viant C, Gaebler C, et al. Naturally enhanced neutralizing breadth against SARS-CoV-2 one year after infection. Nature. 2021;595(7867):426-31. https://doi.org/10.1038/s41586-021-03696-9

126. Wu Q, Ailshire JA, Crimmins EM. Long COVID and symptom trajectory in a representative sample of Americans in the first year of the pandemic. Sci Rep. 2022;12(1):11647. https://doi.org/10.1038/s41598-022-15727-0

127. Yellumahanthi DK, Barnett B, Barnett S, Yellumahanthi S. COVID-19 infection: its lingering symptoms in adults. Cureus. 2022;14(5):e24736. https://doi.org/10.7759/cureus.24736

128. Belkacemi M, Baouche H, Gomis S, Lassalle M, Couchoud C. Long-lasting clinical symptoms 6 months after COVID-19 infection in the French national cohort of patients on dialysis. J Nephrol. 2022;35(3):787-93. https://doi.org/10.1007/s40620-022-01295-z

129. Chan Sui Ko A, Candellier A, Mercier M, Joseph C, Schmit J-L, Lanoix J-P, et al. Number of initial symptoms is more related to long COVID-19 than acute severity of infection: a prospective cohort of hospitalized patients. Int J Infect Dis. 2022;118:220-3. https://doi.org/10.1016/j.ijid.2022.03.006

130. Combret Y, Kerné G, Pholoppe F, Tonneville B, Plate L, Marques MH, et al. Remote assessment of quality of life and functional exercise capacity in a cohort of COVID-19 patients one year after hospitalization (TELECOVID). J Clin Med. 2022;11(4):905. https://doi.org/10.3390/jcm11040905

131. Ghosn J, Piroth L, Epaulard O, Le Turnier P, Mentré F, Bachelet D, et al. Persistent COVID-19 symptoms are highly prevalent 6 months after hospitalization: results from a large prospective cohort. Clin Microbiol Infect. 2021;27(7):1041.e1-4. https://doi.org/10.1016/j.cmi.2021.03.012

132. Jutant EM, Meyrignac O, Beurnier A, Jaïs X, Pham T, Morin L, et al. Respiratory symptoms and radiological findings in post-acute COVID-19 syndrome. ERJ Open Res. 2022;8(2): 00479-2021. https://doi.org/10.1183/23120541.00479-2021

133. Nguyen NN, Hoang VT, Dao TL, Meddeb L, Lagier JC, Million M, et al. Long-term persistence of symptoms of dyspnoea in COVID-19 patients. Int J Infect Dis. 2022;115:17-23. https://doi.org/10.1016/j.ijid.2021.11.035

134. Noel-Savina E, Viatgé T, Faviez G, Lepage B, Mhanna LT, Pontier S, et al. Severe SARS-CoV-2 pneumonia: clinical, functional and imaging outcomes at 4 months. Respir Med Res. 2021;80:100822. https://doi.org/10.1016/j.resmer.2021.100822

135. Pilmis B, Elkaibi I, Péan de Ponfilly G, Daikha H, Bouzid A, Guihot A, et al. Evolution of anti-SARS-CoV-2 immune response in a cohort of French healthcare workers followed for 7 months. Infect Dis Now. 2022;52(2):68-74. https://doi.org/10.1016/j.idnow.2022.01.004

136. Thiolliere F, Falandry C, Allaouchiche B, Geoffray V, Bitker L, Reignier J, et al. Intensive care-related loss of quality of life and autonomy at 6 months post-discharge: Does COVID-19 really make things worse? Crit Care. 2022;26(1):94. https://doi.org/10.1186/s13054-022-03958-6

137. Becker C, Beck K, Zumbrunn S, Memma V, Herzog N, Bissmann B, et al. Long COVID 1 year after hospitalisation for COVID-19: a prospective bicentric cohort study. Swiss Med Wkly. 2021;151:w30091. https://doi.org/10.4414/smw.2021.w30091

138. Benzakour L, Braillard O, Mazzola V, Gex D, Nehme M, Perone SA, et al. Impact of peritraumatic dissociation in hospitalized patients with COVID-19 pneumonia: a longitudinal study. J Psychiatr Res. 2021;140:53-59. https://doi.org/10.1016/j.jpsychires.2021.05.031

139. Cervia C, Zurbuchen Y, Taeschler P, Ballouz T, Menges D, Hasler S, et al. Immunoglobulin signature predicts risk of post-acute COVID-19 syndrome. Nat Commun. 2022;13(1):446. https://doi.org/10.1038/s41467-021-27797-1

140. Desgranges F, Tadini E, Munting A, Regina J, Filippidis P, Viala B, et al. Post-COVID-19 syndrome in outpatients: a cohort study. J Gen Intern Med. 2022;37(8):1943-52. https://doi.org/10.1007/s11606-021-07242-1

141. L'Huillier AG, Pagano S, Baggio S, Meyer B, Andrey DO, Nehme M, et al. Autoantibodies against apolipoprotein A-1 after COVID-19 predict symptoms persistence. Eur J Clin Invest. 2022;52(10):e13818. https://doi.org/10.1111/eci.13818

142. Nehme M, Braillard O, Chappuis F, Courvoisier DS, Guessous I. Prevalence of symptoms more than seven months after diagnosis of symptomatic COVID-19 in an outpatient setting. Ann Intern Med. 2021;174(9):1252-60. https://doi.org/10.7326/m21-0878

143. Nehme M, Braillard O, Chappuis F, Courvoisier DS, Kaiser L, Soccal PM, et al. One-year persistent symptoms and functional impairment in SARS-CoV-2 positive and negative individuals. J Intern Med. 2022;292(1):103-15. https://doi.org/10.1111/joim.13482

144. Tessitore E, Handgraaf S, Poncet A, Achard M, Höfer S, Carballo S, et al. Symptoms and quality of life at 1-year follow up of patients discharged after an acute COVID-19 episode. Swiss Med Wkly. 2021;151(4950):w30093. https://doi.org/10.4414/SMW.2021.w30093

145. Voruz P, Cionca A, Jacot de Alcântara I, Nuber-Champier A, Allali G, Benzakour L, et al. Functional connectivity underlying cognitive and psychiatric symptoms in post-COVID-19 syndrome: is anosognosia a key determinant? Brain Commun. 2022;4(2):fcac057. https://doi.org/10.1093/braincomms/fcac057

146. Arnold DT, Hamilton FW, Milne A, Morley AJ, Viner J, Attwood M, et al. Patient outcomes after hospitalisation with COVID-19 and implications for follow-up: results from a prospective UK cohort. Thorax. 2020;76(4):399-401. https://doi.org/10.1136/thoraxjnl-2020-216086

147. Arnold DT, Donald C, Lyon M, Hamilton FW, Morley AJ, Attwood M, et al. Krebs von den Lungen 6 (KL-6) as a marker for disease severity and persistent radiological abnormalities following COVID-19 infection at 12 weeks. PLoS One. 2021;16(4):e0249607. https://doi.org/10.1371/journal.pone.0249607

148. McPeake J, Shaw M, MacTavish P, Blyth KG, Devine H, Fleming G, et al. Long-term outcomes following severe COVID-19 infection: a propensity matched cohort study. BMJ Open Respir Res. 2021;8(1):e001080. https://doi.org/10.1136/bmjresp-2021-001080

149. Morrow AJ, Sykes R, McIntosh A, Kamdar A, Bagot C, Bayes HK, et al. A multisystem, cardio-renal investigation of post-COVID-19 illness. Nat Med. 2022;28(6):1303-13. https://doi.org/10.1038/s41591-022-01837-9

150. PHOSP-COVID Collaborative Group. Clinical characteristics with inflammation profiling of long COVID and association with 1-year recovery following hospitalisation in the UK: a prospective observational study. Lancet Respir Med. 2022;10(8):761-75. https://doi.org/10.1016/S2213-2600(22)00127-8

151. Sandmann FG, Tessier E, Lacy J, Kall M, Van Leeuwen E, Charlett A, et al. Long-term health-related quality of life in non-hospitalized coronavirus disease 2019 (COVID-19) cases with confirmed severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection in England: longitudinal analysis and cross-sectional comparison with controls. Clin Infect Dis. 2022;75(1):e962-73. https://doi.org/10.1093/cid/ciac151

152. Taylor RR, Trivedi B, Patel N, Singh R, Ricketts WM, Elliott K, et al. Post-COVID symptoms reported at asynchronous virtual review and stratified follow-up after COVID-19 pneumonia. Clin Med. 2021;21(4):e384-91. https://doi.org/10.7861/clinmed.2021-0037

153. Wallis TJ, Heiden E, Horno J, Welham B, Burke H, Freeman A, et al. Risk factors for persistent abnormality on chest radiographs at 12-weeks post hospitalisation with PCR confirmed COVID-19. Respir Res. 2021;22(1):157. https://doi.org/10.1186/s12931-021-01750-8

154. Weber B, Siddiqi H, Zhou G, Vieira J, Kim A, Rutherford H, et al. Relationship between myocardial injury during index hospitalization for SARS-CoV-2 infection and longer-term outcomes. J Am Heart Assoc. 2022;11(1):e022010. https://doi.org/10.1161/JAHA.121.022010

155. Bek LM, Berentschot JC, Heijenbrok-Kal MH, Huijts S, van Genderen ME, Vlake JH, et al. Symptoms persisting after hospitalisation for COVID-19: 12 months interim results of the CO-FLOW study. ERJ Open Res. 2022;8(4):00355-2022. https://doi.org/10.1183/23120541.00355-2022

156. Duivenvoorden R, Vart P, Noordzij M, Soares Dos Santos AC Jr, Zulkarnaev AB, Franssen CF, et al. Clinical, functional, and mental health outcomes in kidney transplant recipients 3 months after a diagnosis of COVID-19. Transplantation. 2022;106(5):1012-23. https://doi.org/10.1097/TP.0000000000004075

157. Janssen MT, Ramiro S, Mostard RL, Magro-Checa C, Landewé RB. Three-month and six-month outcomes of patients with COVID-19 associated hyperinflammation treated with short-term immunosuppressive therapy: follow-up of the CHIC study. RMD Open. 2021;7(3):e001906. https://doi.org/10.1136/rmdopen-2021-001906

158. van den Borst B, Peters JB, Brink M, Schoon Y, Bleeker-Rovers CP, Schers H, et al. Comprehensive health assessment 3 months after recovery from acute coronavirus disease 2019 (COVID-19). Clin Infect Dis. 2021;73(5):e1089-98. https://doi.org/10.1093/cid/ciaa1750

159. van Veenendaal N, van der Meulen IC, Onrust M, Paans W, Dieperink W, van der Voort PH. Six-month outcomes in COVID-19 ICU patients and their family members: a prospective cohort study. Healthcare (Basel). 2021;9(7):865. https://doi.org/10.3390/healthcare9070865

160. Wynberg E, van Willigen HD, Dijkstra M, Boyd A, Kootstra NA, van den Aardweg JG, et al. Evolution of coronavirus disease 2019 (COVID-19) symptoms during the first 12 months after illness onset. Clin Infect Dis. 2021;75(1):e482-90. https://doi.org/10.1093/cid/ciab759

161. García-Grimshaw M, Chirino-Pérez A, Flores-Silva FD, Valdés-Ferrer SI, Vargas-Martínez ML, Jiménez-Ávila AI, et al. Critical role of acute hypoxemia on the cognitive impairment after severe COVID-19 pneumonia: a multivariate causality model analysis. Neurol Sci. 2022;43(4):2217-29. https://doi.org/10.1007/s10072-021-05798-8

162. Gochicoa-Rangel L, Hernández-Morales AP, Salles-Rojas A, Madrid-Mejía W, Guzmán-Valderrábano C, González-Molina A, et al. Gas exchange impairment during COVID-19 recovery. Respir Care. 2021;66(10):1610-7. https://doi.org/10.4187/respcare.09114

163. González-Hermosillo JA, Martínez-López JP, Carrillo-Lampón SA, Ruiz-Ojeda D, Herrera-Ramírez S, Amezcua-Guerra LM, et al. Post-acute COVID-19 symptoms, a potential link with Myalgic Encephalomyelitis/Chronic Fatigue Syndrome: a 6-month survey in a Mexican cohort. Brain Sci. 2021;11(6):760. https://doi.org/10.3390/brainsci11060760

164. Madrid-Mejía W, Gochicoa-Rangel L, Pérez Padilla JR, Salles-Rojas A, González-Molina A, Salas-Escamilla I, et al. Improvement in walking distance lags raise in lung function in post-COVID patients. Arch Bronconeumol. 2022;58(3):261-3. https://doi.org/10.1016/j.arbres.2021.04.027

165. Muñoz-Corona C, Gutiérrez-Canales LG, Ortiz-Ledesma C, Martínez-Navarro LJ, Macías AE, Scavo-Montes DA, et al. Quality of life and persistence of COVID-19 symptoms 90 days after hospital discharge. J Int Med Res. 2022;50(7):3000605221110492. https://doi.org/10.1177/03000605221110492

166. Wong-Chew RM, Rodríguez Cabrera EX, Rodríguez Valdez CA, Lomelin-Gascon J, Morales-Juárez L, de la Cerda ML, et al. Symptom cluster analysis of long COVID-19 in patients discharged from the Temporary COVID-19 Hospital in Mexico City. Ther Adv Infect Dis. 2022;9:20499361211069264. https://doi.org/10.1177/20499361211069264

167. Andrei Appelt P, Taciana Sisconetto A, Baldo Sucupira KS, Neto EM, Chagas TJ, Bazan R, et al. Changes in electrical brain activity and cognitive functions following mild to moderate COVID-19: a one-year prospective study after acute infection. Clin EEG Neurosci. 2022;53(6):543-57. https://doi.org/10.1177/15500594221103834

168. Bretas DC, Leite AS, Mancuzo EV, Prata TA, Andrade BH, Oliveira JD, et al. Lung function six months after severe COVID-19: Does time, in fact, heal all wounds? Braz J Infect Dis. 2022;26(3):102352. https://doi.org/10.1016/j.bjid.2022.102352

169. Freire MP, Oliveira MS, Magri MMC, Tavares BM, Marinho I, Nastri AC, et al. Frequency and factors associated with hospital readmission after COVID-19 hospitalization: the importance of post-COVID diarrhea. Clinics (Sao Paulo). 2022;77:100061. https://doi.org/10.1016/j.clinsp.2022.100061

170. Lopes AJ, Litrento PF, Provenzano BC, Carneiro AS, Monnerat LB, da Cal MS, et al. Small airway dysfunction on impulse oscillometry and pathological signs on lung ultrasound are frequent in post-COVID-19 patients with persistent respiratory symptoms. PLoS One. 2021;16(11):e0260679. https://doi.org/10.1371/journal.pone.0260679

171. Titze-de-Almeida R, da Cunha TR, Dos Santos Silva LD, Ferreira CS, da Silva CP, Ribeiro AP, et al. Persistent, new-onset symptoms and mental health complaints in Long COVID in a Brazilian cohort of non-hospitalized patients. BMC Infect Dis. 2022;22(1):133. https://doi.org/10.1186/s12879-022-07065-3

172. Attauabi M, Dahlerup JF, Poulsen A, et al. Outcomes and long-term effects of COVID-19 in patients with inflammatory bowel diseases - a Danish prospective population-based cohort study with individual-level data. J Crohns Colitis. 2022;16(5):757-67. https://doi.org/10.1093/ecco-jcc/jjab192

173. Bliddal S, Banasik K, Pedersen OB, Nissen J, Cantwell L, Schwinn M, et al. Acute and persistent symptoms in non-hospitalized PCR-confirmed COVID-19 patients. Sci Rep. 2021;11(1):13153. https://doi.org/10.1038/s41598-021-92045-x

174. Nersesjan V, Fonsmark L, Christensen RHB, Amiri M, Merie C, Lebech AM, et al. Neuropsychiatric and cognitive outcomes in patients 6 months after COVID-19 requiring hospitalization compared with matched control patients hospitalized for non-COVID-19 illness. JAMA Psychiatry. 2022;79(5):486-97. https://doi.org/10.1001/jamapsychiatry.2022.0284

175. Petersen MS, Kristiansen MF, Hanusson KD, Foldbo BM, Danielsen ME, Á Steig B, et al. Prevalence of long COVID in a national cohort: longitudinal measures from disease onset until 8 months' follow-up. Int J Infect Dis. 2022;122:437-41. https://doi.org/10.1016/j.ijid.2022.06.031

176. Weihe S, Mortensen CB, Haase N, Andersen LP, Mohr T, Siegel H, et al. Long-term cognitive and functional status in Danish ICU patients with COVID-19. Acta Anaesthesiol Scand. 2022;66(8):978-86. https://doi.org/10.1111/aas.14108

177. Lackermair K, Wilhelm K, William F, Grzanna N, Lehmann E, Sams L, et al. The prevalence of persistent symptoms after COVID-19 disease. Dtsch Arztebl Int. 2022;119(10):175-6. https://doi.org/10.3238/arztebl.m2022.0125

178. Meisinger C, Goßlau Y, Warm TD, Leone V, Hyhlik-Dürr A, Linseisen J, et al. Post-COVID-19 fatigue and SARS-CoV-2 specific humoral and T-cell responses in male and female outpatients. Front Immunol. 2022;13:902140. https://doi.org/10.3389/fimmu.2022.902140

179. Munker D, Veit T, Barton J, Mertsch P, Mümmler C, Osterman A, et al. Pulmonary function impairment of asymptomatic and persistently symptomatic patients 4 months after COVID-19 according to disease severity. Infection. 2022;50(1):157-68. https://doi.org/10.1007/s15010-021-01669-8

180. Staudt A, Jörres RA, Hinterberger T, Lehnen N, Loew T, Budweiser S. Associations of Post-Acute COVID Syndrome with physiological and clinical measures 10 months after hospitalization in patients of the first wave. Eur J Intern Med. 2022;95:50-60. https://doi.org/10.1016/j.ejim.2021.10.031

181. Steinbeis F, Thibeault C, Doellinger F, Ring RM, Mittermaier M, Ruwwe-Glösenkamp C, et al. Severity of respiratory failure and computed chest tomography in acute COVID-19 correlates with pulmonary function and respiratory symptoms after infection with SARS-CoV-2: an observational longitudinal study over 12 months. Respir Med. 2022;191:106709. https://doi.org/10.1016/j.rmed.2021.106709

182. Havervall S, Rosell A, Phillipson M, Mangsbo SM, Nilsson P, Hober S, et al. Symptoms and functional impairment assessed 8 months after mild covid-19 among health care workers. JAMA. 2021;325(19):2015-6. https://doi.org/10.1001/jama.2021.5612

183. Hellgren L, Levi R, Divanoglou A, Birberg-Thornberg U, Samuelsson K. Seven domains of persisting problems after hospital-treated Covid-19 indicate a need for a multiprofessional rehabilitation approach. J Rehabil Med. 2022;54:jrm00301. https://doi.org/10.2340/jrm.v54.2434

184. Kanberg N, Simrén J, Edén A, Andersson LM, Nilsson S, Ashton NJ, et al. Neurochemical signs of astrocytic and neuronal injury in acute COVID-19 normalizes during long-term follow-up. eBioMedicine. 2021;70:103512. https://doi.org/10.1016/j.ebiom.2021.103512

185. Sterky E, Olsson-Åkefeldt S, Hertting O, Herlenius E, Alfven T, Ryd Rinder M, et al. Persistent symptoms in Swedish children after hospitalisation due to COVID-19. Acta Paediatr. 2021;110(9):2578-80. https://doi.org/10.1111/apa.15999

186. Wallin E, Hultström M, Lipcsey M, Frithiof R, Rubertsson S, Larsson I-M. Intensive care-treated COVID-19 patients' perception of their illness and remaining symptoms. Acta Anaesthesiol Scand. 2022;66(2):240-7. https://doi.org/10.1111/aas.13992

187. Emecen AN, Keskin S, Turunc O, Suner AF, Siyve N, Basoglu Sensoy E, et al. The presence of symptoms within 6 months after COVID-19: a single-center longitudinal study. Ir J Med Sci. 2023;192(2):741-50. https://doi.org/10.1007/s11845-022-03072-0

188. Karaarslan F, Güneri FD, Kardeş S. Long COVID: rheumatologic/musculoskeletal symptoms in hospitalized COVID-19 survivors at 3 and 6 months. Clin Rheumatol. 2022;41(1):289-96. https://doi.org/10.1007/s10067-021-05942-x

189. Karadavut S, Altintop I. Long-term cardiovascular adverse events in very elderly COVID-19 patients. Arch Gerontol Geriatr. 2022;100:104628. https://doi.org/10.1016/j.archger.2022.104628

190. Kucukkarapinar M, Yay-Pence A, Yildiz Y, Buyukkoruk M, Yaz-Aydin G, Deveci-Bulut TS, et al. Psychological outcomes of COVID-19 survivors at sixth months after diagnose: the role of kynurenine pathway metabolites in depression, anxiety, and stress. J Neural Transm (Vienna). 2022;129(8):1077-89. https://doi.org/10.1007/s00702-022-02525-1

191. Özcan S, İnce O, Güner A, Katkat F, Dönmez E, Tuğrul S, et al. Long-term clinical consequences of patients hospitalized for COVID-19 infection. Anatol J Cardiol. 2022;26(4):305-15. https://doi.org/10.5152/AnatolJCardiol.2022.924

192. Darcis G, Bouquegneau A, Maes N, Thys M, Henket M, Labye F, et al. Long-term clinical follow-up of patients suffering from moderate-to-severe COVID-19 infection: a monocentric prospective observational cohort study. Int J Infect Dis. 2021;109:209-16. https://doi.org/10.1016/j.ijid.2021.07.016

193. Lorent N, Vande Weygaerde Y, Claeys E, Guler Caamano Fajardo I, Nicolas De Vos N, De Wever W, et al. Prospective longitudinal evaluation of hospitalised COVID-19 survivors 3 and 12 months after discharge. ERJ Open Res. 2022;8(2):00004-2022. https://doi.org/10.1183/23120541.00004-2022

194. Luchian ML, Motoc A, Lochy S, Magne J, Belsack D, De Mey J, et al. Subclinical myocardial dysfunction in patients with persistent dyspnea one year after COVID-19. Diagnostics (Basel). 2021;12(1):57. https://doi.org/10.3390/diagnostics12010057

195. Smith P, Proesmans K, Van Cauteren D, Demarest S, Drieskens S, De Pauw R, et al. Post COVID-19 condition and its physical, mental and social implications: protocol of a 2-year longitudinal cohort study in the Belgian adult population. Arch Public Health. 2022;80(1):151. https://doi.org/10.1186/s13690-022-00906-2

196. Anjana NK, Annie TT, Siba S, Meenu MS, Chintha S, Anish TS. Manifestations and risk factors of post COVID syndrome among COVID-19 patients presented with minimal symptoms - A study from Kerala, India. J Family Med Prim Care. 2021;10(11):4023-9. https://doi.org/10.4103/jfmpc.jfmpc_851_21

197. D'Souza MM, Kaushik A, Dsouza JM, Kanwar R, Lodhi V, Sharma R, et al. Does the initial chest radiograph severity in COVID-19 impact the short- and long-term outcome? - a perspective from India. Infect Dis (Lond). 2022;54(5):335-44. https://doi.org/10.1080/23744235.2021.2018135

198. Meyyappan J, Prasad N, Kushwaha R, Patel M, Behera M, Bhadauria D, et al. Health-related quality of life score and outcomes in living donor renal transplant recipients with COVID-19. Exp Clin Transplant. 2022;20(1):42-51. https://doi.org/10.6002/ect.2021.0332

199. Naik S, Haldar SN, Soneja M, Mundadan NG, Garg P, Mittal A, et al. Post COVID-19 sequelae: a prospective observational study from northern India. Drug Discov Ther. 2021;15(5):254-60. https://doi.org/10.5582/ddt.2021.01093

200. Asadi-Pooya AA, Akbari A, Emami A, Lotfi M, Rostamihosseinkhani M, Nemati H, et al. Long COVID syndrome-associated brain fog. J Med Virol. 2022;94(3):979-84. https://doi.org/10.1002/jmv.27404

201. Sadat Larijani M, Ashrafian F, Bagheri Amiri F, Banifazl M, Bavand A, Karami A, et al. Characterization of long COVID-19 manifestations and its associated factors: a prospective cohort study from Iran. Microb Pathog. 2022;169:105618. https://doi.org/10.1016/j.micpath.2022.105618

202. Simani L, Ramezani M, Darazam IA, Sagharichi M, Aalipour MA, Ghorbani F, et al. Prevalence and correlates of chronic fatigue syndrome and post-traumatic stress disorder after the outbreak of the COVID-19. J Neurovirol. 2021;27(1):154-9. https://doi.org/10.1007/s13365-021-00949-1

203. Czarnowska A, Kapica-Topczewska K, Zajkowska O, Adamczyk-Sowa M, Kubicka-Bączyk K, Niedziela N, et al. Symptoms after COVID-19 infection in individuals with multiple sclerosis in Poland. J Clin Med. 2021;10(22):5225. https://doi.org/10.3390/jcm10225225

204. Malinowska A, Muchlado M, Ślizień Z, Biedunkiewicz B, Heleniak Z, Dębska-Ślizień A, et al. Post-COVID-19 syndrome and decrease in health-related quality of life in kidney transplant recipients after SARS-COV-2 infection—a cohort longitudinal study from the north of Poland. J Clin Med. 2021;10(21):5205. https://doi.org/10.3390/jcm10215205

205. Och A, Tylicki P, Polewska K, Puchalska-Reglińska E, Parczewska A, Szabat K, et al. Persistent Post-COVID-19 Syndrome in hemodialyzed patients-a longitudinal cohort study from the north of Poland. J Clin Med. 2021;10(19):4451. https://doi.org/10.3390/jcm10194451

206. Darley DR, Dore GJ, Byrne AL, Plit ML, Brew BJ, Kelleher A, et al. Limited recovery from post-acute sequelae of SARS-CoV-2 at 8 months in a prospective cohort. ERJ Open Res. 2021;7(4):00384-2021. https://doi.org/10.1183/23120541.00384-2021

207. Hodgson CL, Higgins AM, Bailey MJ, et al. Comparison of 6-month outcomes of survivors of COVID-19 versus non-COVID-19 critical illness. Am J Respir Crit Care Med. 2022;205(10):1159-68. https://doi.org/10.1164/rccm.202110-2335OC

208. Biadsee A, Dagan O, Ormianer Z, Kassem F, Masarwa S, Biadsee A. Eight-month follow-up of olfactory and gustatory dysfunctions in recovered COVID-19 patients. Am J Otolaryngol. 2021;42(4):103065. https://doi.org/10.1016/j.amjoto.2021.103065

209. Klein H, Asseo K, Karni N, Benjamini Y, Nir-Paz R, Muszkat M, et al. Onset, duration and unresolved symptoms, including smell and taste changes, in mild COVID-19 infection: a cohort study in Israeli patients. Clin Microbiol Infect. 2021;27(5):769-74. https://doi.org/10.1016/j.cmi.2021.02.008

210. Blomberg B, Mohn KG-I, Brokstad KA, Zhou F, Linchausen DW, Hansen BA, et al. Long COVID in a prospective cohort of home-isolated patients. Nat Med. 2021;27(9):1607-13. https://doi.org/10.1038/s41591-021-01433-3

211. Søraas A, Kalleberg KT, Dahl JA, Søraas CL, Myklebust TÅ, Axelsen E, et al. Persisting symptoms three to eight months after non-hospitalized COVID-19, a prospective cohort study. PLoS One. 2021;16(8):e0256142. https://doi.org/10.1371/journal.pone.0256142

212. Kashif A, Chaudhry M, Fayyaz T, Abdullah M, Malik A, Anwer JM, et al. Follow-up of COVID-19 recovered patients with mild disease. Sci Rep. 2021;11(1):13414. https://doi.org/10.1038/s41598-021-92717-8

213. Kumar J, Makheja K, Rahul F, Kumar S, Kumar M, Chand M, et al. Long-term neurological impact of COVID-19. Cureus. 2021;13(9):e18131. https://doi.org/10.7759/cureus.18131

214. Osmanov IM, Spiridonova E, Bobkova P, Gamirova A, Shikhaleva A, Andreeva M, et al. Risk factors for post COVID-19 condition in previously hospitalised children using the ISARIC Global follow-up protocol: a prospective cohort study. Eur Respir J. 2022;59(2):2101341. https://doi.org/10.1183/13993003.01341-2021

215. Pazukhina E, Andreeva M, Spiridonova E, Bobkova P, Shikhaleva A, El-Taravi Y, et al. Prevalence and risk factors of post-COVID-19 condition in adults and children at 6 and 12 months after hospital discharge: a prospective, cohort study in Moscow (StopCOVID). BMC Med. 2022;20(1):244. https://doi.org/10.1186/s12916-022-02448-4

216. Kim Y, Bitna H, Kim S-W, Chang HH, Kwon TK, Bae S, et al. Post-acute COVID-19 syndrome in patients after 12 months from COVID-19 infection in Korea. BMC Infect Dis. 2022;22(1):93. https://doi.org/10.1186/s12879-022-07062-6

217. Kim Y, Kim SW, Chang HH, Kwon KT, Hwang S, Bae S. One year follow-up of COVID-19 related symptoms and patient quality of life: a prospective cohort study. Yonsei Med J. 2022; 63(6):499-510. https://doi.org/10.3349/ymj.2022.63.6.499

218. Sonnweber T, Grubwieser P, Sahanic S, Böhm AK, Pizzini A, Anna Luger A, et al. The impact of iron dyshomeostasis and anaemia on long-term pulmonary recovery and persisting symptom burden after COVID-19: a prospective observational cohort study. Metabolites. 2022;12(6):546. https://doi.org/10.3390/metabo12060546

219. Labarca G, Henriquez-Beltran M, Llerena F, Erices G, Lastra J, Enos D, et al. Undiagnosed sleep disorder breathing as a risk factor for critical COVID-19 and pulmonary consequences at the midterm follow-up. Sleep Med. 2022;91:196-204. https://doi.org/10.1016/j.sleep.2021.02.029

220. Nafakhi A, Rabeea IS, Al-Darraji R, Al-Darraji R, Nafakhi H, Mechi A, et al. Association of ABO blood group with in-hospital adverse outcome and long term persistent symptoms of COVID-19 infection: a single-center longitudinal observational study. Health Sci Rep. 2022;5(3):e656. https://doi.org/10.1002/hsr2.656

221. O'Brien K, Townsend L, Dowds J, Bannan C, Nadarajan P, Kent B, et al. 1-year quality of life and health-outcomes in patients hospitalised with COVID-19: a longitudinal cohort study. Respir Res. 2022;23(1):115. https://doi.org/10.1186/s12931-022-02032-7

222. Miyazato Y, Morioka S, Tsuzuki S, Akashi M, Osanai Y, Tanaka K, et al. Prolonged and late-onset symptoms of coronavirus disease 2019. Open Forum Infect Dis. 2020;7(11):ofaa507. https://doi.org/10.1093/ofid/ofaa507

223. Alharthy A, Abuhamdah M, Balhamar A, Faqihi F, Nasim N, Ahmad S, et al. Residual lung injury in patients recovering from COVID-19 critical illness: a prospective longitudinal point-of-care lung ultrasound study. J Ultrasound Med. 2021;40(9):1823-8. https://doi.org/10.1002/jum.15563

224. Ercegovac M, Asanin M, Savic-Radojevic A, Ranin J, Matic M, Djukic T, et al. Antioxidant genetic profile modifies probability of developing neurological sequelae in long-COVID. Antioxidants (Basel). 2022;11(5):954. https://doi.org/10.3390/antiox11050954

225. Ong SW, Fong SW, Young BE, Chan YH, Lee B, Amrun SN, et al. Persistent symptoms and association with inflammatory cytokine signatures in recovered coronavirus disease 2019 patients. Open Forum Infect Dis. 2021;8(6):ofab156. https://doi.org/10.1093/ofid/ofab156

226. Soliman IW, Leaver S, Flaatten H, Fjølner J, Wernly B, Bruno RR, et al. Health-related quality of life in older patients surviving ICU treatment for COVID-19: results from an international observational study of patients older than 70 years. Age Ageing. 2022; 51(2):afab278. https://doi.org/10.1093/ageing/afab278

227. Sudre CH, Murray B, Varsavsky T, Graham MS, Penfold RS, Bowyer RC, et al. Attributes and predictors of long COVID. Nat Med. 2021;27(4):626-31. https://doi.org/10.1038/s41591-021-01292-y

228. Volberding PA, Bernice X. Chu BX, Carol Mason Spicer CM, editors. Long-term health effects of COVID-19: disability and function following SARS-CoV-2 infection [Internet]. Washington (DC): National Academies Press; 2024 [cited 2024 May 05]. https://doi.org/10.17226/27756

229. Behnood SA, Shafran R, Bennett SD, Zhang AX, O'Mahoney LL, Stephenson TJ, et al. Persistent symptoms following SARS-CoV-2 infection amongst children and young people: a meta-analysis of controlled and uncontrolled studies. J Infect. 2022;84(2): 158-70. https://doi.org/10.1016/j.jinf.2021.11.011

230. Office for National Statistics. Prevalence of ongoing symptoms following coronavirus (COVID-19) infection in the UK: 2 September 2021 [Internet]. Newport (UK): Office for National Statistics; 2021 Sep 02 [cited 2024 May 05]. Available from: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/bulletins/prevalenceofongoingsymptomsfollowingcoronaviruscovid19infectionintheuk/2september2021

231. Government of Canada. COVID-19: Longer-term symptoms among Canadian adults – First report [Internet]. Ottawa (ON): Health Infobase Canada; [updated 2023 Mar 24; cited 2024 May 05]. Available from: https://health-infobase.canada.ca/covid-19/post-covid-condition/fall-2022-report.html

232. Chen C, Haupert SR, Zimmermann L, Shi X, Fritsche LG, Mukherjee B. Global prevalence of post-coronavirus disease 2019 (COVID-19) condition or long COVID: a meta-analysis and systematic review. J Infect Dis. 2022;226(9): 1593-607. https://doi.org/10.1093/infdis/jiac136

233. Han Q, Zheng B, Daines L, Sheikh A. Long-term sequelae of COVID-19: a systematic review and meta-analysis of one-year follow-up studies on post-COVID symptoms. Pathogens. 2022; 11(2):269. https://doi.org/10.3390/pathogens11020269

234. Huang Q, Jia M, Sun Y, Jiang B, Cui D, Feng L, et al. One-year temporal changes in long COVID prevalence and characteristics: a systematic review and meta-analysis. Value Health. 2023;26(6):934-42. https://doi.org/10.1016/j.jval.2022.11.011

235. Ma Y, Deng J, Liu Q, Du M, Liu M, Liu J. Long-term consequences of COVID-19 at 6 months and above: a systematic review and meta-analysis. Int J Environ Res Public Health. 2022; 19(11):6865. https://doi.org/10.3390/ijerph19116865

236. Ma Y, Deng J, Liu Q, Du M, Liu M, Liu J. Long-term consequences of asymptomatic SARS-CoV-2 infection: a systematic review and meta-analysis. Int J Environ Res Public Health. 2023;20(2): 1613. https://doi.org/10.3390/ijerph20021613

237. Maglietta G, Diodati F, Puntoni M, Lazzarelli S, Marcomini B, Patrizi L, et al. Prognostic factors for Post-COVID-19 Syndrome: a systematic review and meta-analysis. J Clin Med. 2022;11(6): 1541. https://doi.org/10.3390/jcm11061541

238. O'Mahoney LL, Routen A, Gillies C, Ekezie W, Welford A, Zhang A, et al. The prevalence and long-term health effects of Long Covid among hospitalised and non-hospitalised populations: a systematic review and meta-analysis. EClinicalMedicine. 2022;55:101762. https://doi.org/10.1016/j.eclinm.2022.101762

239. Zeng N, Zhao YM, Yan W, Li C, Lu QD, Liu L, et al. A systematic review and meta-analysis of long term physical and mental sequelae of COVID-19 pandemic: call for research priority and action. Mol Psychiatry. 2023;28(1):423-33. https://doi.org/10.1038/s41380-022-01614-7

240. Statistics on COVID-19 [Internet]. Stockholm (SE): Socialstyrelsen (National Board of Health and Welfare-Sweden); [updated 2024 Mar 14; cited 2024 May 05]. Available from: https://www.socialstyrelsen.se/en/statistics-and-data/statistics/statistics-subjects/statistics-on-covid-19/

241. The Australian Institute of Health and Welfare. Long COVID in Australia – a review of the literature [Internet]. Canberra (AU): AIHW; 2022 Dec 16 [cited 2024 May 05] [Catalogue No.: PHE 318]. https://doi.org/10.25816/6jqy-5e35

242. Subramaniam A, Lim ZJ, Ponnapa Reddy M, Shekar K. Systematic review and meta-analysis of the characteristics and outcomes of readmitted COVID-19 survivors. Intern Med J. 2021;51(11):1773-780. https://doi.org/10.1111/imj.15350

243. Pekar-Carpenter K, Siddiqi A, Catanzarite N, Chase J, McMillon A, Shouse B. Long COVID [Internet]. Washington (DC): US Government Accountability Office; [cited 2024 May 05] [Report No.; GAO-22-105666]. Available from: https://www.gao.gov/assets/gao-22-105666.pdf

244. European Centre for Disease Prevention and Control. Prevalence of post COVID-19 condition symptoms: a systematic review and meta-analysis of cohort study data stratified by recruitment setting [Internet]. Stockholm (SE): ECDC; 2022 Oct 27 [cited 2024 May 05]. Available from: https://www.ecdc.europa.eu/sites/default/files/documents/Prevalence-post-COVID-19-condition-symptoms.pdf

245. Alkodaymi MS, Omrani OA, Fawzy NA, Shaar BA, Almamlouk R, Riaz M, et al. Prevalence of post-acute COVID-19 syndrome symptoms at different follow-up periods: a systematic review and meta-analysis. Clin Microbiol Infect. 2022;28(5):657-66. https://doi.org/10.1016/j.cmi.2022.01.014

246. Healey Q, Sheikh A, Daines L, Vasileiou E. Symptoms and signs of long COVID: a rapid review and meta-analysis. J Glob Health. 2022;12:05014. https://doi.org/10.7189/jogh.12.05014

247. Sanchez-Ramirez DC, Normand K, Zhaoyun Y, Torres-Castro R. Long-term impact of COVID-19: a systematic review of the literature and meta-analysis. Biomedicines. 2021;9(8):900. https://doi.org/10.3390/biomedicines9080900

248. Yang T, Yan MZ, Li X, Lau EH. Sequelae of COVID-19 among previously hospitalized patients up to 1 year after discharge: a systematic review and meta-analysis. Infection. 2022;50(5):1067-109. https://doi.org/10.1007/s15010-022-01862-3

249. Ceban F, Ling S, Lui LMW, Lee Y, Gill H, Teopiz KM, et al. Fatigue and cognitive impairment in Post-COVID-19 Syndrome: a systematic review and meta-analysis. Brain, Behav Immun. 2022;101:93-135. https://doi.org/10.1016/j.bbi.2021.12.020

250. Premraj L, Kannapadi NV, Briggs J, Seal SM, Battaglini D, Fanning J, et al. Mid and long-term neurological and neuropsychiatric manifestations of post-COVID-19 syndrome: a meta-analysis. J Neurol Sci. 2022;434:120162. https://doi.org/10.1016/j.jns.2022.120162

251. Fernández-de-Las-Peñas C, Navarro-Santana M, Plaza-Manzano G, Palacios-Ceña D, Arendt-Nielsen L. Time course prevalence of post-COVID pain symptoms of musculoskeletal origin in patients who had survived severe acute respiratory syndrome coronavirus 2 infection: a systematic review and meta-analysis. Pain. 2022;163(7):1220-31. https://doi.org/10.1097/j.pain.0000000000002496

252. Bourmistrova NW, Solomon T, Braude P, Strawbridge R, Carter B. Long-term effects of COVID-19 on mental health: a systematic review. J Affect Disord. 2022;299:118-25. https://doi.org/10.1016/j.jad.2021.11.031

253. Morrison A, Polisena J, Husereau D, Moulton K, Clark M, Fiander M, et al. The effect of English-language restriction on systematic review-based meta-analyses: a systematic review of empirical studies. Int J Technol Assess Health Care. 2012;28(2):138-44. https://doi.org/10.1017/S0266462312000086

254. Hilton Boon M, Thomson H, Shaw B, Akl EA, Lhachimi SK, López-Alcalde J, et al. Challenges in applying the GRADE approach in public health guidelines and systematic reviews: a concept article from the GRADE Public Health Group. J Clin Epidemiol. 2021;135:42-53. https://doi.org/10.1016/j.jclinepi.2021.01.001

255. Sk Abd Razak R, Ismail A, Abdul Aziz AF, Suddin LS, Azzeri A, Sha'ari NI. Post-COVID syndrome prevalence: a systematic review and meta-analysis. BMC Public Health. 2024;24(1):1785. https://doi.org/10.1186/s12889-024-19264-5

256. Domingo FR, Waddell LA, Cheung AM, Cooper CL, Belcourt VJ, Zuckermann AM, et al. Prevalence of long-term effects in individuals diagnosed with COVID-19: an updated living systematic review. MedRxiv [Preprint]. 2021 [cited 2024 May 05]:2021.06. 03.21258317. Available from: https://www.medrxiv.org/content/10.1101/2021.06.03.21258317v2

https://doi.org/10.24095/hpcdp.45.3.03

With thanks to our 2024 peer reviewers

We are grateful to the following individuals for their significant contribution to *Health Promotion and Chronic Disease Prevention in Canada* as peer reviewers in 2024. Their expertise ensures the quality of our journal and promotes the sharing of new knowledge among peers in Canada and internationally.

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Other PHAC publications

Researchers from the Public Health Agency of Canada also contribute to work published in other journals and books. Look for the following articles published in 2024 and 2025:

Chaput JP, Morin CM, Robillard R, Carney CE, Dang-Vu T, Davidson JR, […] **Lang JJ**. Trends in nighttime insomnia symptoms in Canada from 2007 to 2021. Sleep Med. 2025;125:21-6. https://doi.org/10.1016/j.sleep.2024.11.025

Chen R, **Gilbert NL**, Dubé È. Adult influenza vaccination coverage before, during and after the COVID-19 pandemic in Canada. BMC Public Health. 2024;24(1):3357. https://doi.org/10.1186/s12889-024-20854-6

Clayborne ZM, **Wong SL**, **Roberts KC**, **Prince SA**, **Gariépy G**, Goldfield GS, […] **Lang JJ**. Associations between social media use and positive mental health among adolescents: findings from the Canadian Health Behaviour in School-aged Children Study. J Psychiatr Res. 2025;181:333-9. https://doi.org/10.1016/j.jpsychires.2024.11.071

Doan N, **Lang JJ**, **Roberts KC**, Manyanga T, Rainham DG, **Capaldi CA**, **Butler G**, **Prince SA**, **Srugo SA**. Investigating the independent and synergistic associations between neighbourhood greenness and physical activity in relation to perceived mental health among adults in Canada. Int J Environ Health Res. 2024:1-12. https://doi.org/10.1080/09603123.2024.2426712

Jibb L, **Laverty M**, Johnston DL, Rayar M, Truong TH, Kulkarni K, […] **Kaur J**, **Winch N**, et al. Association between socioeconomic factors and childhood acute lymphoblastic leukemia treatment- and survival-related outcomes in Canada. Pediatr Blood Cancer. 2025;72(2):e31472. https://doi.org/10.1002/pbc.31472

Kamal A, Balachandra T. A review of accidental residential fire death investigations in Alberta 2012–2021. Can Soc Forensic Sci J. 2024:1-15. https://doi.org/10.1080/00085030.2024.2430422

Liu L, **Contreras G**, **Pollock NJ**, **Thompson W**. Suicidal ideation among Canadian adults during the third year of the COVID-19 pandemic compared to pre- and early pandemic periods. Ment Health Prev. 2024;36:200379. https://doi.org/10.1016/j.mhp.2024.200379

Liu L, **Pollock NJ**, **Contreras G**, **Xu Y**, **Thompson W**. Self-harm hospitalizations and neighbourhood level material and social deprivation in Canada: an ecological study. BMC Psychiatry. 2024;24(1):859. https://doi.org/10.1186/s12888-024-06316-8

Macneil A, Taunque A, Leo SN, Li G, **de Groh M**, **Jiang Y**, et al. The mental health toll of the COVID-19 pandemic on older adults with migraine: a prospective analysis of depression using the Canadian Longitudinal Study on Aging. J Pain Res. 2024;17:3845-66. https://doi.org/10.2147/JPR.S469798

Richmond N, Ornstein A, **Tonmyr L**, **Dzakpasu S**, **Nelson C**, **Pollock NJ**. Child maltreatment mortality in Canada: an analysis of coroner and medical examiner data. Child Abuse Negl. 2025;159:107127. https://doi.org/10.1016/j.chiabu.2024.107127

Roy E, Jaeger B, Evans AM, Turetsky KM, O'Shea BA, Petersen MB, […] **Gretton JD**, et al. A contest study to reduce attractiveness-based discrimination in social judgment. J Pers Soc Psychol. 2024. https://doi.org/10.1037/pspa0000414

Rushton B, Lemieux CJ, Scott DJ, Halpenny EA, Tompkins J, Jones B, […] **Prince SA**, et al. Future-proofing nature-based tourism in Canada: a horizon scan of emerging challenges. Curr Issues Tourism. 2024. https://doi.org/10.1080/13683500.2024.2431526

Slota JA, **Lamoureux L**, **Frost KL**, **Sajesh BV**, **Booth SA**. Single-cell transcriptomics unveils molecular signatures of neuronal vulnerability in a mouse model of prion disease that overlap with Alzheimer's disease. Nat Commun. 2024;15(1):10174. https://doi.org/10.1038/s41467-024-54579-2

https://doi.org/10.24095/hpcdp.45.6.06

Corrigendum

Global prevalence of post-COVID-19 condition: a systematic review and meta-analysis of prospective evidence

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This corrigendum is being published to correct a number of errors and imprecisions, on pages 113, 120–125 and 138, of the following article:

Taher MK, Salzman T, Banal A, Morissette K, Domingo FR, Cheung AM, Cooper CL, Boland L, Zuckermann AM, Mullah MA, Laprise C, Colonna R, Hashi A, Rahman P, Collins E, Corrin T, Waddell LA, Pagaduan JE, Ahmad R, Jaramillo Garcia AP. Global prevalence of post-COVID-19 condition: a systematic review and meta-analysis of prospective evidence. Health Promot Chronic Dis Prev Can. 2025;45(3):112-38. https://doi.org/10.24095/hpcdp.45.3.02

The authors would like to clarify a few points specifically related to the referencing of results from the 2023 Canadian COVID-19 Antibody and Health Survey (CCAHS).[1] These clarifications reflect refinements in how the source data are interpreted and attributed, and do not affect the core findings or conclusions of the review. Bold has been used to identify the changes and updated text.

1. p. 113, middle column, paragraph 2:

Before correction

Results from recent population surveys conducted to assess the overall prevalence of PCC symptoms among adults vary from 14.3% in the USA[15] to 6.8% in Canada[16] and 4.7% in Australia.[17]

After correction

Results from recent population surveys conducted to assess the **prevalence** of PCC symptoms among adults vary from 14.3% in the USA[15] to **11.7%** in Canada[16] and 4.7% in Australia.[17]

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2. p. 120, last column, paragraph 3 and p. 125, first column, paragraph 1:

The changes made in the following paragraph include the addition of a new reference, numbered 257 for convenience. The statement regarding higher PCC prevalence among females, individuals hospitalized during acute infection and those with pre-existing chronic conditions was previously attributed only to a Statistics Canada table which did not include all of those breakdowns. The new reference (see item 3, below) contains the comprehensive data supporting this statement.

Before correction

Results of the 2023 Canadian COVID-19 Antibody and Health Survey (CCAHS) revealed that nearly 20% of COVID-19 survivors (6.8% of adults in Canada) experienced PCC symptoms.[16] Of this group, nearly 80% continued to experience these symptoms for 6 months or longer, and more than 40% for a year or longer.[16] Earlier results reported that prevalence was higher among females, those initially hospitalized for severe COVID-19 and individuals with preexisting chronic conditions.[18] Common symptoms reported from Cycle 1 of the survey included fatigue (72.1%), dyspnea (38.5%) and brain fog (32.9%).[231]

After correction

Results of the 2023 Canadian COVID-19 Antibody and Health Survey (CCAHS) revealed that nearly 20% of COVID-19 survivors experienced PCC symptoms.[16] **This corresponds to 11.7% of the total adult population, or approximately 3.5 million Canadians. Among those who experienced PCC symptoms during the time of the survey (6.8%),** nearly 80% continued to experience these symptoms for 6 months or longer, and more than 40% for a year or longer.[16] Earlier results reported that prevalence **of PCC among COVID-19 survivors** was higher among females, those initially hospitalized for severe COVID-19 and individuals with preexisting chronic conditions.[18,257] Common symptoms reported from **Cycle 2** of the survey included fatigue (72.1%), dyspnea (38.5%) and brain fog (32.9%).[231]

3. p. 138, new reference:

257. Government of Canada. COVID-19: Longer-term symptoms among Canadian adults – Second report [Internet]. Ottawa (ON): Health Infobase Canada; [updated 2024 Aug 21; cited 2025 May 13]. Available from: https://health-infobase.canada.ca/covid-19/post-covid-condition/spring-2023-report.html#a6

Reference

1. Kuang S, Earl S, Clarke J, Zakaria D, Demers A, Aziz S. Experiences of Canadians with longterm symptoms following COVID-19. Ottawa (ON): Statistics Canada; 2023. Available from: https://www150.statcan.gc.ca/n1/pub/75-006-x/2023001/article/00015-eng.htm