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All-cause healthcare resource utilization and costs among community-managed adults with long-COVID in France, 2020–2023

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ABSTRACT

Background: The clinical and economic burden of long COVID is poorly understood. We aim to assess all-cause healthcare resource utilization (HCRU) and costs in the primary care setting among adults with long COVID in France.

Methods: A retrospective cohort study using the electronic healthcare records (EHRs) of confirmed and/or probable COVID-19 patients from The Health Improvement Network (THIN) data between March 2020 and December 2022 was conducted. Long COVID was identified per World Health Organization (WHO) definition as suggestive symptoms present ≥ 3 months following acute SARS-CoV-2 infection. Patients' characteristics, HCRU, direct healthcare and indirect costs (National Health Insurance-based prices) were summarized. Costs between patients with previous SARS-CoV-2 infection who developed long COVID, patients with previous SARS-CoV-2 infection who did not develop long COVID (COVID only), and contemporaneous controls without SARS-CoV-2 infection were compared (Non-COVID).

Results: Long COVID developed among 30,122 (11.6%) adults; mean (SD) age was 50 (17) years, 63.6% were female and 27.5% had a Charlson Comorbidity Index score >2 . During the post-infection follow-up (mean = 13 months), 97.3% of patients had general practitioner consultations (GP) and 62.4% had nursing care. Costs were highest during the first post-diagnosis year with per patient per year costs of €2,443 (total cost of €52 million), including costs for GP (€208) and specialist (€170) consultations, outpatient procedures (€413), retail pharmacy use (€595), biological testing (€147), and medical device usage (€172). Patients with long COVID had additional costs of €163 and €176 when compared to patients in the COVID only and Non-COVID cohorts, respectively.

Limitations: Since the THIN database is generated from GP EHRs, there is the possibility of measurement/documentation errors and missing values which could compromise the validity and accuracy of certain results.

Conclusion: Long COVID was associated with non-negligible HCRU, direct and indirect costs to the French healthcare system. These findings reinforce the importance of optimizing long-term resource allocation for patients infected with SARS-CoV-2.

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Introduction

Long COVID, also referred to as post-COVID-19 condition, post-acute COVID-19 syndrome, and post-acute sequelae of COVID-19, is a multisystemic condition comprising a wide range of symptoms that follow an acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection. The most frequent symptoms include: shortness of breath, fatigue, muscle weakness or joint stiffness, sleep disturbances, decreased mental and cognitive status, olfactory dysfunction, cough, mood changes, chest pain, stomach pain, and

headache^{1,2}. Although several independent health authorities have developed long COVID guidelines, there is no universally accepted definition of long COVID^{3,4}. The National Institute for Health and Care Excellence (NICE) defined long COVID as “new or ongoing symptoms four weeks or more after the start of acute COVID-19,” with signs and symptoms of COVID-19 from 4–12 weeks and for >12 weeks with no alternative diagnostic explanation⁵. The World Health Organization (WHO) defined it as a condition characterized by symptoms impacting everyday life, which occur after a history of probable or confirmed SARS-CoV-2 infection;

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symptoms occur three months from the onset of acute illness, last for ≥ 2 months, and cannot be explained by an alternative diagnosis⁶.

The prevalence of long COVID varies widely depending on the definition of long COVID, study design/setting and geographic location⁷. In 2022, Santé publique France reported a 4% prevalence of long COVID among the adult general population and 8% for adults with a SARS-CoV-2 infection ≥ 3 months earlier⁸. Among a longitudinal prospective French cohort of patients hospitalized with COVID-19, 42% had 1–2 persistent symptoms three months post-discharge and 27% had ≥ 3 persistent symptoms⁹. Moreover, two prospective cohort studies of 311 and 429 adults in France with mild outpatient-treated COVID-19 reported that 46.3% and 43.7% had persistent symptoms at six weeks and thirty days following an acute SARS-CoV-2 infection, respectively^{10,11}. Although most of the existing studies assessing the burden of long COVID have focused on hospitalized patients, mild-moderate infections that are managed in primary care settings account for more than 80% of COVID cases. Therefore, it is important to understand both the clinical and economic burden of longer-term health outcomes of COVID-19 infection in this population^{1,12,13}.

Prior studies assessing healthcare resource utilization (HCRU) and costs in long COVID patients have shown a significant burden to the healthcare system^{14–24}. However, these studies utilized a wide range of clinical definitions, time frames, patient populations, and data sources. In addition, while these studies included several European countries, the economic burden of long COVID in France remains unclear^{14–18}. Furthermore, the majority of long COVID patients in France are managed by general practitioners (GPs) in primary care settings, and therefore the present study aimed to quantify all-cause HCRU and costs among community-managed long COVID patients aged ≥ 18 years in France from 2020 to 2023²⁵.

Methods

Data source

The Health Improvement Network (THIN[®]) database, a large standardized European database, contains anonymized EHR collected from about 2,000 GPs in retail practice in France participating the THIN network²⁶. The database included physician-collected patient demographic characteristics, medical and prescription information from more than 14 million visits from >4.5 million active patients and the patient history of 40 million patients. The THIN GP database is representative of the total National Institute of Statistics and Economic Studies (INSEE) population of France based on gender, age and region^{26,27}.

Study design and population

This retrospective cohort study identified adults (age ≥ 18 years) diagnosed with COVID-19 during March 2020 to December 2022 from the THIN GP EHR database using

International Classification of Diseases, Tenth Revision (ICD-10) diagnosis code U07.1. The index date was the first confirmed or probable diagnosis of COVID-19. Long COVID was identified per the WHO definition⁶. The symptoms (Supplementary Table 1) were new-onset or persisting following initial acute infection, could fluctuate or relapse over time, and were not explained by an alternative diagnosis (Supplementary Appendix 1). The follow-up period began three months post-index and continued for ≤ 21 months (two years following the acute infection) or was censored at patient death, reinfection (defined as a new COVID-19 diagnosis that occurred between 3–21 months after the index date), last recorded contact with a THIN physician (loss to follow-up), or end of the study period, whichever occurred first. Sensitivity analyses on NICE-defined long COVID were also performed, beginning one month following the acute infection. These patients were also required to meet the aforementioned inclusion and exclusion criteria.

Covariates

Patient demographics were evaluated at the index date. Quan-Charlson Comorbidity index (CCI) scores were based on the last known CCI score prior to the index date. Clinical characteristics were determined using the most recent data available prior to and including the index date. Community-managed long COVID-associated HCRU and costs were evaluated among patients with ≥ 1 any-cause healthcare reimbursement ≥ 3 months after the index date.

All-cause HCRU and costs

All-cause HCRU and costs were evaluated among community-managed long COVID patients with ≥ 1 any-cause healthcare reimbursement starting at 3 months following the acute infection per WHO definition (starting at 1 month per NICE definition in the sensitivity analyses) during both the total and first 12 months of the follow-up period. Burden was estimated and reported as the number and percentage of patients with the HCRU, mean cost per patient, percentage of the total cost, and cost per patient per year (PPPY). The mean cost per patient was calculated as the total cost during the study time period, divided by the total number of patients included in the cost analysis. The percentage of the total corresponds to the portion of HCRU-related costs out of the total cost. PPPY corresponds to the total costs divided by the number of months of follow-up, multiplied by 12. To determine the costs associated with the consumption of care, total HCRU and costs associated with healthcare received after a diagnosis of long COVID were stratified into seven areas of care: healthcare encounters, medical procedures, retail pharmacy usage, biological testing procedures, sick leave, medical transport, and medical device usage (Supplementary Appendix 2). In France, sick leave and medical transport services (e.g. ambulance, taxi) are covered by social security for insured individuals, and the associated reimbursement data were collected in the THIN database. For sick leave, the daily allowance provided by social security

is as follows: only 50% of the salary is covered by health insurance, up to a maximum of €52 per day^{28,29}. In our study, we applied an average daily reimbursement of €41 for sick leaves. Similarly, medical transportation is based on an average reimbursement amount of €58 per trip^{30,31}.

Statistical analysis

Descriptive statistics were used to summarize baseline characteristics, HCRU and costs. Counts and percentages were reported for categorical variables. Continuous variables were summarized using means and standard deviations (SD) for normally distributed variables and medians and interquartile range (IQR) for variables with skewed distribution. Analyses of reimbursement data were performed on patients with a recorded reimbursement history. The specialist-related healthcare encounters, medical procedure classifications, and retail pharmacy treatment types that accounted for the ten highest proportions of healthcare costs for the associated care areas were reported. In addition, we compared the direct healthcare costs of patients who developed long COVID (Long COVID cohort) with that of patients previously infected with SARS-CoV-2 who did not develop long COVID (COVID Only cohort) and contemporaneous uninfected controls (Non-COVID cohort) using multivariate regression models. Non-COVID cohort patients were randomly selected from among a population of 4.5 million patients who were not diagnosed with a SARS-CoV-2 infection using a stratification method and assigned an index date based on the first healthcare encounter that occurred between 1 March 2020 and 31 December 2022. Stratification was performed based on the following criteria: age at the index date (in 10-year age groups), available follow-up time (0 to 5 months, then in 10-month periods from the index date), health seeking behaviour prior to the index date (GP interaction history within a 2-year period prior to the index date), and gender. All analyses were performed using R software.

Results

Among the 259,184 patients with a confirmed and/or probable COVID-19 diagnosis between March 2020 and December 2022, the prevalence of WHO-defined long COVID was 11.6% ($n=30,120$, [Supplementary Figure 1](#)). Among patients initially identified with at least one WHO-defined long COVID symptom, 49.2% were subsequently excluded when their symptoms were explained by alternative diagnoses other than COVID infection (e.g. existing chronic conditions). Patients with long COVID had a mean (SD) age of 50 (17) years; the majority were female ([Table 1](#)). Patients on average had a mild comorbidity burden and tended to be overweight. Among WHO-defined long COVID patients, 34.3% of patients were lost to follow-up and 33.9% were followed until the end of the study period. Most patients were not reinfected with COVID-19 during the post-long COVID follow-up period ($n=25,989$, 86.3%). Assessment of the incidence of long COVID according to the SARS-CoV-2 variant predominant at the time of acute infection revealed that the

Table 1. Patient demographic and clinical characteristics.

| | Adults with WHO-defined long COVID ($n=30,120$) |
|--|---|
| Age (years) at index date | |
| Mean (SD) | 50 (17) |
| Median (IQR) | 50 (25) |
| Age group (years) at index date, n (%) | |
| 18–64 | 23,538 (78.1%) |
| ≥65 | 6,582 (21.9%) |
| Sex, n (%) | |
| Female | 19,161 (63.6%) |
| Male | 10,959 (36.4%) |
| Charlson comorbidity index (CCI) | |
| Mean (SD) | 1.7 (2.0) |
| Median | 1 (3) |
| CCI per class, n (%) | |
| 0 | 10,244 (34.0%) |
| 1–2 | 10,772 (35.8%) |
| 3–4 | 5,099 (16.9%) |
| >4 | 2,875 (9.5%) |
| Missing | 1,130 (3.8%) |
| Body mass index (BMI) ^a | |
| Mean (SD) | 26.9 (6.0) |
| Median (IQR) | 26.1 (7.6) |
| BMI class, n (%) | |
| <18.5 | 535 (4.0%) |
| 18.5–<25 | 5,053 (37.9%) |
| 25–<30 | 4,189 (31.5%) |
| ≥30 | 3,541 (26.6%) |
| Follow-up duration, months | |
| Mean (SD) | 13 (6) |
| Median (IQR) | 14 (13) |
| Lost to follow-up, n (%) | |
| Reinfection | 895 (3.0%) |
| Others ^b | 9,426 (31.3%) |

Abbreviations. IQR, interquartile range; SD, standard deviation; WHO, World Health Organization.

^aBMI was only available in 13,318 individuals per WHO definition.

^bOther reasons included patients who no longer required medical attention during the study period, death or consultation with GPs outside the representative network.

Omicron BA.1 variant led to the highest incidence of long COVID ([Supplementary Figure 2](#))^{32,33}.

Among patients with WHO-defined long COVID, 83.6% had a reimbursement history and were included in the HCRU and cost analysis. The total all-cause cost after a diagnosis of long COVID over the follow-up period was €66.6 million, with mean total costs per patient of €2,645 ([Table 2](#)). The majority of the healthcare services were consumed during the first year following SARS-CoV-2 infection. Sick leave accounted for the largest proportion of long COVID costs, followed by retail pharmacy use, medical procedures and healthcare encounters; 76.5% to 78.9% of these costs were incurred within the first year of follow-up. Nearly all patients (97.8%) had a healthcare encounter within the first 12 months. GP-related care accounted for 55% of the total cost of healthcare encounters and was received by approximately 94% of patients during both the overall follow-up period and the first year following the initial infection ([Table 3](#)). Non-nursing specialists accounted for approximately 38% of the total cost of healthcare encounters during the overall and first year of follow-up. Lastly, approximately 60% of patients were treated by a nurse during the overall and first year of follow-up, which accounted for 6.7% of healthcare encounter-related costs.

Among long COVID patients included in the cost analysis, 86.0% and 84.4% had a medical procedure during the overall and first year of follow-up, respectively. Dental surgery and

Table 2. Healthcare resource utilization and costs of adults with WHO-defined long COVID during the total and first year of the follow-up period.

| Treatment type | Total follow-up (n = 25,187) | | | | First year of follow-up (n = 24,730) | | | |
|-------------------------------|------------------------------|-----------------|-----------------|-------|--------------------------------------|-----------------|-----------------|-------|
| | HCRU N (%) | Cost, € | | | HCRU N (%) | Cost, € | | |
| | | Mean per person | % of total cost | PPPY | | Mean per person | % of total cost | PPPY |
| Total | 25,187 (100.0%) | 2,645 | 100.0% | 2,302 | 24,730 (100.0%) | 2,061 | 100.0% | 2,443 |
| Healthcare encounters | 24,514 (97.3%) | 404 | 15.3% | 352 | 24,175 (97.8%) | 325 | 15.5% | 378 |
| Medical procedures | 21,656 (86.0%) | 443 | 16.7% | 385 | 20,861 (84.4%) | 355 | 16.9% | 413 |
| Pharmacy use | 24,241 (96.2%) | 647 | 24.4% | 563 | 23,857 (96.5%) | 511 | 24.4% | 595 |
| Biological testing procedures | 20,095 (79.8%) | 156 | 5.9% | 136 | 19,328 (78.2%) | 126 | 6.0% | 147 |
| Sick leave | 6,922 (27.5%) | 777 | 29.4% | 677 | 6,238 (25.2%) | 606 | 28.9% | 705 |
| Medical transport | 2,840 (11.3%) | 34 | 1.3% | 29 | 2,468 (10.0%) | 27 | 1.3% | 31 |
| Medical device use | 15,061 (59.8%) | 184 | 7.0% | 160 | 13,785 (55.7%) | 148 | 7.1% | 172 |

Abbreviations. HCRU, healthcare resource utilization; PPPY, per patient per year; WHO, World Health Organization.

Table 3. Top 10 healthcare encounter utilization and costs during the total and first year of the follow-up period of adults with WHO-defined long COVID.

| Physician specialty | Total follow-up (n = 25,187) | | | | First year of follow-up (n = 24,730) | | | |
|--------------------------|------------------------------|-----------------|-----------------|------|--------------------------------------|-----------------|-----------------|------|
| | HCRU N (%) | Cost, € | | | HCRU N (%) | Cost, € | | |
| | | Mean per person | % of total cost | PPPY | | Mean per person | % of total cost | PPPY |
| Any healthcare encounter | 24,514 (97.3%) | 404 | 100.0% | 352 | 24,175 (97.8%) | 325 | 100.0% | 378 |
| General medicine | 23,695 (94.1%) | 222 | 54.8% | 193 | 23,284 (94.2%) | 179 | 55.1% | 208 |
| Nurse | 15,716 (62.4%) | 27 | 6.7% | 23 | 14,696 (59.4%) | 22 | 6.7% | 25 |
| Physiotherapist | 7,906 (31.4%) | 18 | 4.4% | 15 | 7,196 (29.1%) | 14 | 4.4% | 17 |
| Inpatient psychiatry | 1,312 (5.2%) | 17 | 4.3% | 15 | 1,196 (4.8%) | 14 | 4.3% | 16 |
| Inpatient cardiology | 3,268 (13.0%) | 10 | 2.5% | 9 | 2,804 (11.3%) | 8 | 2.5% | 9 |
| Osteopathy | 2,971 (11.8%) | 9 | 2.3% | 8 | 2,537 (10.3%) | 7 | 2.3% | 9 |
| Gynaecology-obstetrics | 3,986 (15.8%) | 8 | 2.0% | 7 | 3,455 (14.0%) | 7 | 2.0% | 8 |
| Dental surgery | 5,880 (23.3%) | 8 | 2.0% | 7 | 4,957 (20.0%) | 7 | 2.0% | 8 |
| Dermatology | 3,688 (14.6%) | 8 | 2.0% | 7 | 3,120 (12.6%) | 6 | 2.0% | 7 |
| Anesthesia resuscitation | 3,920 (15.6%) | 7 | 1.8% | 6 | 3,217 (13.0%) | 6 | 1.8% | 7 |

Abbreviations. HCRU, healthcare resource utilization; PPPY, per patient per year; WHO, World Health Organization.

Table 4. Top 10 medical procedure utilization and costs during the total and first year of the follow-up period of adults with WHO-defined long COVID.

| Medical procedures ^a | Total follow-up (n = 25,187) | | | | First year of follow-up (n = 24,730) | | | |
|---------------------------------------|------------------------------|-----------------|-----------------|------|--------------------------------------|-----------------|-----------------|------|
| | HCRU N (%) | Cost, € | | | HCRU N (%) | Cost, € | | |
| | | Mean per person | % of total cost | PPPY | | Mean per person | % of total cost | PPPY |
| Any medical procedure | 21,656 (86.0%) | 443 | 100.0% | 385 | 20,861 (84.4%) | 355 | 100.0% | 413 |
| Other not applicable or <100 patients | 18,705 (74.3%) | 184 | 41.5% | 160 | 17,658 (71.4%) | 148 | 41.7% | 172 |
| Dental surgery | 12,212 (48.5%) | 102 | 23.1% | 89 | 10,816 (43.7%) | 82 | 23.0% | 95 |
| Ophthalmology | 8,903 (35.3%) | 41 | 9.2% | 36 | 7,602 (30.7%) | 33 | 9.2% | 38 |
| Inpatient cardiology | 3,789 (15.0%) | 14 | 3.2% | 12 | 3,257 (13.2%) | 12 | 3.3% | 14 |
| Anatomical and cytopathology | 4,276 (17.0%) | 12 | 2.8% | 11 | 3,536 (14.3%) | 10 | 2.7% | 11 |
| Pneumology | 1,861 (7.4%) | 11 | 2.5% | 10 | 1,609 (6.5%) | 9 | 2.6% | 11 |
| Otorhinolaryngology (E.N.T.) | 2,617 (10.4%) | 11 | 2.5% | 10 | 2,239 (9.1%) | 9 | 2.6% | 11 |
| General medicine | 3,708 (14.7%) | 10 | 2.2% | 9 | 3,123 (12.6%) | 8 | 2.3% | 9 |
| Osteopathy | 910 (3.6%) | 9 | 2.1% | 8 | 722 (2.9%) | 7 | 2.0% | 8 |
| Hepato-gastroenterology | 1,404 (5.6%) | 9 | 2.0% | 8 | 1,134 (4.6%) | 7 | 2.0% | 8 |

Abbreviations. HCRU, healthcare resource utilization; PPPY, per patient per year; WHO, World Health Organization.

^aMedical procedures were categorized using Classification Commune des Actes Médicaux (CCAM) classifications, a French clinical procedure coding system.

ophthalmology accounted for the highest proportion of total medical procedure-related costs and were the most commonly performed procedures (Table 4). Few patients had a pneumology-related procedure during the follow-up period and only approximately 3% of annual medical procedure costs were pneumology-related. In addition, more than 96% of patients had retail pharmacy use during both the overall and first year of follow-up. Antineoplastics and immunomodulating agents, digestive system and metabolic treatments, nervous system-related treatment classes accounted for the highest proportions of retail pharmacy costs (Table 5). Although antineoplastics and immunomodulating agents accounted for the largest proportion of pharmacy costs, only 4.1% of patients received these treatments during follow-up; digestive system and metabolic treatments and nervous system-related treatments were received by the vast majority of

patients. Respiratory system-related pharmacological treatments were received by approximately 60% of patients during the overall and first year of follow-up but represented only 7.4% of total retail pharmacy costs during both periods.

In the sensitivity analyses, evaluation of long COVID using NICE criteria resulted in a prevalence of 14.4% (n = 37,446). Aside from the follow-up duration, the distribution of patient demographics and clinical characteristics were similar to that of WHO-defined long COVID patients (Supplementary Table 2). Furthermore, the relative proportions of HCRU and costs attributed to the studied areas of care were also similar to that of patients with WHO-defined long COVID (Supplementary Tables 3–6).

In the multivariate analysis, patients with long COVID had additional costs of €163 compared to patients in the COVID Only cohort (p < 0.05), after adjusting for gender, age, CCI,

Table 5. Top 10 retail pharmacy utilization and costs during the total and first year of the follow-up period of adults with WHO-defined long COVID.

| Retail pharmacy ^a | Total follow-up (n = 25,187) | | | | First year of follow-up (n = 24,730) | | | |
|---|------------------------------|---------|-----------------|-----------------|--------------------------------------|---------|--------|-----------------|
| | HCRU | Cost, € | | | HCRU | Cost, € | | |
| | | N (%) | Mean per person | % of total cost | | PPPY | N (%) | Mean per person |
| Any pharmacy use | 24,241 (96.2%) | 647 | 100.0% | 563 | 23,857 (96.5%) | 511 | 100.0% | 595 |
| Antineoplastics and immunomodulating agents | 1,087 (4.3%) | 183 | 28.3% | 159 | 1,013 (4.1%) | 145 | 28.3% | 169 |
| Digestive system and metabolism | 19,830 (78.7%) | 78 | 12.1% | 68 | 19,018 (76.9%) | 60 | 11.8% | 70 |
| Nervous system | 21,363 (84.8%) | 73 | 11.2% | 63 | 20,634 (83.4%) | 58 | 11.3% | 67 |
| Systemic anti-infectives | 16,003 (63.5%) | 60 | 9.3% | 52 | 14,802 (59.9%) | 47 | 9.2% | 55 |
| Blood and blood-forming organs | 8,030 (31.9%) | 55 | 8.5% | 48 | 7,376 (29.8%) | 45 | 8.7% | 52 |
| Cardiovascular system | 10,264 (40.8%) | 51 | 7.8% | 44 | 9,918 (40.1%) | 40 | 7.7% | 46 |
| Respiratory system | 15,509 (61.6%) | 48 | 7.4% | 42 | 14,393 (58.2%) | 38 | 7.4% | 44 |
| Sensory organs | 8,977 (35.6%) | 28 | 4.4% | 25 | 8,007 (32.4%) | 23 | 4.5% | 27 |
| Dermatology | 12,214 (48.5%) | 16 | 2.5% | 14 | 11,003 (44.5%) | 12 | 2.3% | 14 |
| Genitourinary system and sex hormones | 7,408 (29.4%) | 16 | 2.5% | 14 | 6,832 (27.6%) | 13 | 2.6% | 15 |

Abbreviations. HCRU, healthcare resource utilization; PPPY, per patient per year; WHO, World Health Organization.

^aRetail pharmacy use was categorized by treatment type.

body mass index (BMI) and prior health seeking behaviour (Supplementary Table 7). The adjusted comparison of the total healthcare costs of the Long COVID and Non-COVID cohorts revealed increased costs of €176 among patients with long COVID ($p < 0.05$) (Supplementary Table 8).

Discussion

Our study has shown that the clinical and economic burden of patients with long COVID managed in the community in France was non-negligible, particularly within the first year following SARS-CoV-2 infection, as more than 97% of the patients had an all-cause healthcare encounter. Comparison of total healthcare costs across three cohorts revealed that patients with long COVID had higher costs compared to patients who did not develop long COVID or were not infected with COVID, which further demonstrated that long COVID poses an additional economic burden to the healthcare system. Sick leave, pharmacy use, and medical procedures accounted for more than 70% of all costs, resulting in a total cost of €66.6 and €51.9 million to the French healthcare system during the 2-year span and first year following acute SARS-CoV-2 infection, respectively. Our findings demonstrated the importance of long COVID management, which is vital to mitigate its clinical and economic burdens from a national payer perspective.

The prevalence of long COVID in adults has been extensively reviewed and synthesized in the literature, but the reported estimation has a large variation depending on the population of interest, study setting, diagnostic criteria used to identify acute infection, definition of long COVID, and methods of data collection and interpretation^{7,34–36}. It was reported that in autumn 2022, the prevalence of long COVID in French adult population ranged from 1.2% to 13.4%, depending on the definition³⁷. A cross-sectional survey in France using random sampling from August to November 2022 found that, among participants reporting probable or confirmed infection, 8.0% met the WHO definition of long COVID; Delta variant and Omicron BA.1 waves represented the highest infections⁸. However, symptoms were self-reported, and data were collected in autumn 2022, potentially introducing recall bias for infections from earlier waves, which may explain the slightly

lower prevalences observed in their study and the government report compared to our estimates³⁸. Although we were not able to compare the prevalence of NICE-defined long COVID in our study with the estimate presented in Coste et al.⁸, given that it was reported only in participants with perceived long COVID, a similar agreement between the two definitions has been observed.

In the present study, primary care providers are the first point of contact for patients experiencing persistent symptoms. Prior studies conducted in Europe generally supported our findings^{15–17}. For instance, a retrospective case series study that consisted of 267 adult patients managed in the primary care setting in Spain has shown that 98.4% of long COVID patients required at least one contact with a primary care provider, with an average of 6.7 contacts¹⁶. Notably, nurses and physiotherapists also play crucial roles in the management of long COVID patients in our analyses, which is consistent with a retrospective study from 30 European countries indicating that nurses provided medical care alongside GPs³⁹. In particular, nurses in France and Italy were responsible for performing antigenic tests and delivering the results along with retail pharmacists. Also, it has been well acknowledged that long COVID patients are not only experiencing physical conditions but also mental health symptoms and conditions^{40,41}, requiring a holistic approach to rehabilitation to ensure a gradual return to normal function where physiotherapists can monitor progress and adjust treatment as needed⁴². However, according to a focus group study conducted in Germany in 2022, patients who had a primary care encounter due to long COVID did not perceive it as helpful due to the lack of support received to improve their symptoms, citing factors such as a low awareness of long COVID and poor access to specialists⁴³. Although some studies have proposed evidence-based primary care guidelines for the management of long COVID patients, it is vital to formalize an international framework to facilitate long COVID diagnosis and identification, provide symptom-based treatment, and coordinate multidisciplinary care in this endemic phase^{42,44–46}.

Since long COVID is recognized as a clinical syndrome with a spectrum of manifestations, often presenting as symptom clusters that indicate interconnected pathophysiological mechanisms, we reported the all-cause HCRU of long COVID

patients to holistically quantify clinical and economic burden instead of aiming to establish any causality between the diagnosis and resource utilized⁴⁷. We have observed high demands for dental surgery, followed by ophthalmology in the present study. Rafalowicz et al.⁴⁸ reported oral cavity symptoms among long COVID patients in a longitudinal study in Poland, which included discoloration, ulceration, and haemorrhagic changes on the oral mucosa, although the exact mechanism of SARS-CoV-2 infection in the development of oral conditions remains unclear⁴⁹. Interestingly, Chakraborty et al.⁵⁰ conducted a review of long COVID and its implications on dental management, revealing that there might be a delayed delivery of oral surgeries due to prolonged symptoms in long COVID patients which may partially explain the “rebound effect” observed in the present study. Similarly, evidence of long COVID-associated ophthalmic complications is emerging⁵¹, and the high usage of ophthalmology among long COVID patients indicates a call for longer-term surveillance, as the eye could be subject to secondary infection⁵².

It is worth mentioning that over 95% of the long COVID patients in our study had pharmacy use, with medications for the nervous, digestive, metabolic, and respiratory systems and systemic anti-infectives ranked among the top five; such usage could be explained by the symptoms most frequently observed among long COVID patients. According to a systematic review of the symptoms among long COVID patients, fatigue and shortness of breath were the most frequent symptoms⁵³, which is supported by a similar review of patients with mild SARS-CoV-2 infections². In a retrospective cohort study comprised of non-hospitalized COVID patients from the Netherlands and Belgium, over 90% of the participants reported fatigue approximately 3 months after infection¹³. Aside from neurological and cardiopulmonary symptoms, gastrointestinal symptoms are also prevalent, highlighting the importance of providing personalized, symptom-specific care⁵⁴.

Regarding the cost of community-managed long COVID patients, the data are sparse. To the best of our knowledge, this is the first study quantifying the economic burden of long COVID in France. Among 536 adults with long COVID (13.4%) from a statutory health insurance company in Germany, mean (SD) healthcare costs within the first year after SARS-CoV-2 infection were €1,074 (€1,057) for outpatient medical care and €480 (€1,519) for drug costs¹⁴. In Israel, patients with diagnosed or probable long COVID had mean (SD) monthly costs at 12 months of \$1,284 (\$8,031) for physician visits, \$20 (\$280) for dispensed medications, and \$699 (\$1,070) for lab tests and imaging, with a total cost of \$3,989 (\$14,984)²⁰. A UK study of 472,173 non-hospitalized adults with a diagnosis of long COVID and those with long COVID symptoms reported mean PPPY costs for PC consultations of £94 and £130, respectively¹⁸. Our estimates are within the range of the aforementioned studies. However, it is difficult to directly compare the costs across studies, as the healthcare system and reimbursement methodology are country-dependent and ways of managing long COVID are heterogeneous. While we found that diagnosis of long COVID triggered incremental costs

compared to COVID only or non-COVID patients, there is a gap in the literature to help us further evaluate our estimates. Future studies are needed to quantify the magnitude of the economic burden that is attributed to long COVID.

Notably, sick leave due to long COVID underscores a significant indirect cost in the current study, which has been observed in prior studies^{15,16,19,55,56}. The symptoms of long COVID often impact daily functioning, interfering with the ability to work. In an online survey of people with suspected and confirmed COVID-19 from 56 countries, 45.2% had reduced work schedules and another 22.3% were no longer working or on sick/disability leave¹⁹. When referred to a dedicated post-COVID-19 clinical service in the UK, 25% to 36% of patients had not returned to work¹⁵. Another study of 222 patients who received care at the University Hospital of Cologne's post-COVID outpatient clinic reported that, at 15 months post-infection, 24.8% of patients had not returned to work; 14.9% were on sick leave⁵⁵. In the case series of 122 adults with long COVID from Spain, 41.8% required work leave during the follow-up period¹⁶. Gandjour Afschin estimated a production loss of €3.4 billion and nearly 0.4% of employees were expected to be either fully or partially withdrawn from the labour market per 2020–2021 data from Germany⁵⁶. Hence, future studies are needed to better capture the monetary costs of long COVID on labour supply, production and incomes.

Limitations

The findings of this study should be interpreted in the context of several limitations. First, since the THIN database is generated from GP EHRs, there is the possibility of measurement/documentation errors, missing values, data gaps, or variable physician coding which could compromise the validity and accuracy of certain results. However, quality controls are employed throughout the data collection process to minimize such errors. In France, the “Assurance Maladie” entails a physician/GP who coordinates and centralizes all patient care and information. Patient information from partially reimbursed hospitalizations, consultations with other private or THIN observatory physicians or non-referred specialists may not be captured, resulting in potential underestimation of long COVID-associated conditions. Second, identification of clinical conditions relied on adapting definitions established by health authorities to the database; there may be discrepancies between medical assessment and algorithm coding. Third, patients with undiagnosed asymptomatic COVID-19 were not included in the study. The estimated risk of developing long COVID after an asymptomatic/mild vs asymptomatic infection is 80% lower⁵⁷. While the milder long COVID symptoms of asymptomatic patients are less costly to treat, asymptomatic cases account for a significant proportion of SARS-CoV-2 infections⁵⁸. Consequently, our study likely provides a conservative estimate of the economic burden of long COVID. Fourth, this study set COVID episode durations at 12 weeks, which may fail to differentiate between ongoing infection and possible reinfection. However, this should affect few individuals as most persons without severe

immunocompromising conditions are not expected to experience a single episode of ongoing infection beyond 12 weeks. Fifth, since we reported all-cause HCRU and costs in long COVID, some of the healthcare services received may not be long COVID-related. For example, the most expensive drug costs are antineoplastic and immunomodulating agents which may be explained by patients with underlying conditions, e.g. cancer, and are unlikely to be the consequence of long COVID. However, it has been reported that cancer survivors have higher odds of developing long COVID when compared with non-cancer individuals from a U.S. study and cancer is one of the important predictors of long COVID following mild SARS-CoV-2 infection^{59,60}. Future studies are needed with defined methodology to better capture long-COVID-specific costs. Moreover, the lack of a control arm and baseline data in the current study may prevent us from uncovering the true incremental burden of long COVID, and our results therefore should be interpreted with caution. Sixth, it is worth noting that 34% of patients were considered to be lost to follow-up, which could be attributed to one of the following reasons: (1) patients no longer needed medical attention during the study period of interest; (2) death; and (3) patients consulted GPs outside the representative network. Since we were not able to identify those who had recovered and patient vital status was not captured in the database, the loss to follow-up rate was amplified. As a result, our estimate of HCRU is likely conservative and potential selection bias can be introduced, limiting the generalizability of our findings. Lastly, the perspective of our cost analysis is the healthcare system in France. However, the true cost of medical consultations is likely underestimated given the extra charges commonly invoiced by GPs and specialists were not captured. Also, other indirect costs, such as informal caregiving, are not taken into consideration.

Conclusion

Long COVID is associated with non-negligible HCRU, direct medical costs, and indirect costs to the French healthcare system. Our results reinforce the importance of optimizing long-term resource allocation for patients previously infected with SARS-CoV-2.

Transparency

Declaration of funding

This work was supported by Pfizer.

Declaration of financial/other interests

JY, AB, PAS, JLN, MLB, HRV, JR and SF are Pfizer employees and may hold Pfizer stock. The remaining authors have no declarations.

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Author contributions

The study design was developed by JY, CT and EA. CT and EA collected and analysed the data. JY, CT, EA, AB, PAS, JLN, HRV, SF, MLB, JR, HBR,

OR and PC participated in the interpretation of data and critical review of the manuscript for important intellectual content. All authors had full access to all the data in the study and decided to submit the paper for publication.

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Data availability statement

The data underlying this article were provided by THIN under licence/by permission. Access to anonymized patient data from THIN is subject to a data-sharing agreement containing detailed terms and conditions of use following protocol approval from THIN. The data underlying this article are available in the article and in its online supplementary material. Further queries can be directed to the corresponding author at jingyan.yang@pfizer.com.

References

- [1] Subramanian A, Nirantharakumar K, Hughes S, et al. Symptoms and risk factors for long COVID in non-hospitalized adults. *Nat Med*. 2022;28(8):1706–1714. doi: [10.1038/s41591-022-01909-w](https://doi.org/10.1038/s41591-022-01909-w).
- [2] van Kessel SAM, Olde Hartman TC, Lucassen P, et al. Post-acute and long-COVID-19 symptoms in patients with mild diseases: a systematic review. *Fam Pract*. 2022;39(1):159–167. doi: [10.1093/fampra/cmab076](https://doi.org/10.1093/fampra/cmab076).
- [3] Munblit D, O'Hara ME, Akrami A, et al. Long COVID: aiming for a consensus. *Lancet Respir Med*. 2022;10(7):632–634. doi: [10.1016/S2213-2600\(22\)00135-7](https://doi.org/10.1016/S2213-2600(22)00135-7).
- [4] Yang J, Markus K, Andersen KM, et al. Definition and measurement of post-COVID-19 conditions in real-world practice: a global systematic literature review. *BMJ Open*. 2024;14(1):e077886. doi: [10.1136/bmjopen-2023-077886](https://doi.org/10.1136/bmjopen-2023-077886).
- [5] National Institute for Health and Care Excellence: Clinical Guidelines. COVID-19 rapid guideline: managing the long-term effects of COVID-19. London: National Institute for Health and Care Excellence (NICE); 2024.
- [6] World Health Organization. A clinical case definition of post COVID-19 condition by a Delphi consensus. Geneva, Switzerland: World Health Organization; 2021 [updated 2021 Oct 6; cited 2024 Mar 19]. Available from: https://www.who.int/publications/i/item/WHO-2019-nCoV-Post_COVID-19_condition-Clinical_case_definition-2021.1
- [7] Woodrow M, Carey C, Ziauddeen N, et al. Systematic review of the prevalence of long COVID. *Open Forum Infect Dis*. 2023;10(7):ofad233.
- [8] Coste J, Delpierre C, Richard JB, et al. Prevalence of long COVID in the general adult population according to different definitions and sociodemographic and infection characteristics. A nationwide random sampling survey in France in autumn 2022. *Clin Microbiol Infect*. 2024;30(7):924–929.
- [9] Ghosn J, Piroth L, Epaulard O, 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 e1–1041 e4.
- [10] Armange L, Bénédit F, Picard L, et al. Prevalence and characteristics of persistent symptoms after non-severe COVID-19: a prospective cohort study. *Eur J Clin Microbiol Infect Dis*. 2021;40(11):2421–2425. doi: [10.1007/s10096-021-04261-y](https://doi.org/10.1007/s10096-021-04261-y).
- [11] Faycal A, Ndoadoumgue AL, Sellem B, et al. Prevalence and factors associated with symptom persistence: a prospective study of 429 mild COVID-19 outpatients. *Infect Dis Now*. 2022;52(2):75–81. doi: [10.1016/j.idnow.2021.11.003](https://doi.org/10.1016/j.idnow.2021.11.003).

- [12] Vance H, Maslach A, Stoneman E, et al. Addressing post-COVID symptoms: a guide for primary care physicians. *J Am Board Fam Med.* 2021;34(6):1229–1242. doi: [10.3122/jabfm.2021.06.210254](https://doi.org/10.3122/jabfm.2021.06.210254).
- [13] Goërtz YMJ, Van Herck M, Delbressine JM, et al. Persistent symptoms 3 months after a SARS-CoV-2 infection: the post-COVID-19 syndrome? *ERJ Open Res.* 2020;6(4):00542–2020. doi: [10.1183/23120541.00542-2020](https://doi.org/10.1183/23120541.00542-2020).
- [14] Brandt F, Simone G, Loth J, et al. COVID-19-associated costs and mortality in Germany: an incidence-based analysis from a payer's perspective. *BMC Health Serv Res.* 2024;24(1):321. doi: [10.1186/s12913-024-10838-y](https://doi.org/10.1186/s12913-024-10838-y).
- [15] Heightman M, Prashar J, Hillman TE, et al. Post-COVID-19 assessment in a specialist clinical service: a 12-month, single-centre, prospective study in 1325 individuals. *BMJ Open Respir Res.* 2021;8(1):e001041.
- [16] Rogero-Blanco E, Medina-García R, Jerez-Fernández P, et al. Long COVID prevalence, follow-up and use of resources in primary care: a confirmed case series study. *Res Square.* 2022. doi: [10.21203/rs.3.rs-2353263/v1](https://doi.org/10.21203/rs.3.rs-2353263/v1).
- [17] Valdivieso-Martínez B, Sauri I, Philibert J, et al. Impact of long-COVID on health care burden: a case control study. *J Clin Med.* 2023;12(18):5768. doi: [10.3390/jcm12185768](https://doi.org/10.3390/jcm12185768).
- [18] Tufts J, Guan N, Zemedikun DT, et al. The cost of primary care consultations associated with long COVID in non-hospitalised adults: a retrospective cohort study using UK primary care data. *BMC Prim Care.* 2023;24(1):245. doi: [10.1186/s12875-023-02196-1](https://doi.org/10.1186/s12875-023-02196-1).
- [19] Davis HE, Assaf GS, McCorkell L, et al. Characterizing long COVID in an international cohort: 7 months of symptoms and their impact. *EclinMed.* 2021;38:101019. doi: [10.1016/j.eclinm.2021.101019](https://doi.org/10.1016/j.eclinm.2021.101019).
- [20] Tene L, Bergroth T, Eisenberg A, et al. Risk factors, health outcomes, healthcare services utilization, and direct medical costs of patients with long COVID. *Int J Infect Dis.* 2023;128:3–10. doi: [10.1016/j.ijid.2022.12.002](https://doi.org/10.1016/j.ijid.2022.12.002).
- [21] Koumpias AM, Schwartzman D, Fleming O. Long-haul COVID: healthcare utilization and medical expenditures 6 months post-diagnosis. *BMC Health Serv Res.* 2022;22(1):1010. doi: [10.1186/s12913-022-08387-3](https://doi.org/10.1186/s12913-022-08387-3).
- [22] McNaughton CD, Austin PC, Sivaswamy A, et al. Post-acute health care burden after SARS-CoV-2 infection: a retrospective cohort study. *CMAJ.* 2022;194(40):E1368–E1376. doi: [10.1503/cmaj.220728](https://doi.org/10.1503/cmaj.220728).
- [23] Tartof SY, Malden DE, Liu IA, et al. Health care utilization in the 6 months following SARS-CoV-2 infection. *JAMA Netw Open.* 2022; 5(8):e2225657. doi: [10.1001/jamanetworkopen.2022.25657](https://doi.org/10.1001/jamanetworkopen.2022.25657).
- [24] Katz GM, Bach K, Bobos P, et al. Understanding how post-COVID-19 condition affects adults and health care systems. *JAMA Health Forum.* 2023;4(7):e231933. doi: [10.1001/jamahealthforum.2023.1933](https://doi.org/10.1001/jamahealthforum.2023.1933).
- [25] Davin-Casalena B, Lutaud R, Scronias D, et al. French general practitioners frequently see patients with long-COVID. *J Am Board Fam Med.* 2021;34(5):1010–1013. doi: [10.3122/jabfm.2021.05.210142](https://doi.org/10.3122/jabfm.2021.05.210142).
- [26] lordache L, Strazzulla A, Lekens B, et al. Évaluation du suivi des recommandations de prise en charge des infections urinaires en médecine de ville en France. *Médecine et Maladies Infectieuses.* 2018;48(4, Supplement):S101–S102.
- [27] Autorité de Santé H. Systèmes de mesure du glucose interstitiel, couplés ou non à une pompe à insuline, et systèmes de boucle semi-fermée pour la gestion automatisée du diabète. Haute Autorité de Santé. Paris, France; 2023 [updated 2024 Jul 23; cited 2025 Feb 4]. Available from: <https://www.has-sante.fr/upload/docs/application/pdf/2024-09/rapport.pdf>
- [28] l'Assurance Maladie. Montants maximum des indemnités journalières (IJ) l'Assurance Maladie: l'Assurance Maladie; 2025 [updated 2025 Jan 1; cited 2025 Jan 28]. Available from: <https://www.ameli.fr/ain/entreprise/vos-salaries/montants-reference/indemnitees-journalieres-montants-maximum>
- [29] Direction de la Recherche des Études de l'Évaluation et des Statistiques (DREES). Arrêts maladie: au-delà des effets de la crise sanitaire, une accélération depuis. Paris, France: l'Assurance Maladie; 2019 [updated 2024 Dec 2024; cited 2025 Jan 25]; No 1321. Available from: https://drees.solidarites-sante.gouv.fr/sites/default/files/2024-12/ER1321_0.pdf
- [30] l'Assurance Maladie. Le remboursement des frais de transport l'Assurance Maladie: l'Assurance Maladie; 2024 [updated 2024 Apr 2; cited 2024 Jan 28]. Available from: <https://www.ameli.fr/ain/taxi-conventionne/exercice-professionnel/prise-charge-transport/taux-remboursement>
- [31] Sécurité Sociale L. 3.2 Les dépenses de transport et leurs disparités régionales France: la Sécurité Sociale; 2016 [updated 2016 Jun; cited 2025 Jan 28]. Available from: https://www.securite-sociale.fr/files/live/sites/SSFR/files/medias/CCSS/2016/FICHE_ECLAIRAGE/JUIN/CCSS-FICHE_ECLAIRAGE-SEPTEMBRE_2016-LES_DEPENSES_DE_TRANSPORT_ET_LEURS_DISPARITES_REGIONALES.pdf
- [32] Santé publique France. InfoCOVIDFrance: key numbers and evolution of COVID-19 in France and worldwide - Variants Paris, Paris, France: Santé publique France; 2023 [updated 2023 Jun 28; cited 2024 Apr 12]. Available from: <https://www.santepubliquefrance.fr/dossiers/coronavirus-covid-19/coronavirus-chiffres-cles-et-evolution-de-la-covid-19-en-france-et-dans-le-monde>
- [33] Santé publique France. Acute respiratory infections (influenza, bronchiolitis, COVID-19). Paris, France: Santé publique France; 2024 [updated 2024 Feb 8; cited 2024 Apr 12]. Available from: <https://www.santepubliquefrance.fr/maladies-et-traumatismes/maladies-et-infections-respiratoires/grippe/documents/bulletin-national/infections-respiratoires-aigues-grippe-bronchiolite-covid-19--bulletin-du-7-fevrier-2024>
- [34] Sk Abd Razak R, Ismail A, Abdul Aziz AF, et al. Post-COVID syndrome prevalence: a systematic review and meta-analysis. *BMC Public Health.* 2024;24(1):1785. doi: [10.1186/s12889-024-19264-5](https://doi.org/10.1186/s12889-024-19264-5).
- [35] Estrada-Codécido J, Chan AK, Andany N, et al. Prevalence and predictors of persistent post-COVID-19 symptoms. *J Assoc Med Microbiol Infect Dis Can.* 2022;7(3):208–219. doi: [10.3138/jammi-2022-0013](https://doi.org/10.3138/jammi-2022-0013).
- [36] O'Mahoney LL, Routen A, Gillies C, et al. The prevalence and long-term health effects of Long Covid among hospitalised and non-hospitalised populations: a systematic review and meta-analysis. *EclinMed.* 2023;55:101762. doi: [10.1016/j.eclinm.2022.101762](https://doi.org/10.1016/j.eclinm.2022.101762).
- [37] Coste J, Delpierre C, Tebeka S, et al. Difference in long COVID prevalence due to different definitions and long COVID related risk factors. *Eur J Public Health.* 2024;34(Supplement_3):iii316. doi: [10.1093/eurpub/ckae144.811](https://doi.org/10.1093/eurpub/ckae144.811).
- [38] Santé publique France. Enquête "COVID long - Affection post-COVID-19, France métropolitaine", septembre-novembre 2022, premiers résultats. Paris, France: Santé publique France; 2023 [updated 2023 Jun 21; cited 2025 Feb 3]. Available from: <https://www.santepubliquefrance.fr/maladies-et-traumatismes/maladies-et-infections-respiratoires/infection-a-coronavirus/documents/enquetes-etudes/enquete-covid-long-affection-post-covid-19-france-metropolitaine-septembre-novembre-2022-premiers-resultats>
- [39] Guisado-Clavero M, Ares-Blanco S, Serafini A, et al. The role of primary health care in long-term care facilities during the COVID-19 pandemic in 30 European countries: a retrospective descriptive study (Eurodata study). *Prim Health Care Res Dev.* 2023;24:e60. doi: [10.1017/S1463423623000312](https://doi.org/10.1017/S1463423623000312).
- [40] Hawke LD, Nguyen ATP, Wang W, et al. Systematic review of interventions for mental health, cognition and psychological wellbeing in long COVID. *BMJ Ment Health.* 2024;27(1):e301133. doi: [10.1136/bmjment-2024-301133](https://doi.org/10.1136/bmjment-2024-301133).
- [41] Hawke LD, Nguyen ATP, Ski CF, et al. Interventions for mental health, cognition, and psychological wellbeing in long COVID: a systematic review of registered trials. *Psychol Med.* 2022;52(13):2426–2440. doi: [10.1017/S0033291722002203](https://doi.org/10.1017/S0033291722002203).
- [42] Owen R, Ashton REM, Ferraro FV, et al. Forming a consensus opinion to inform long COVID support mechanisms and interventions: a modified Delphi approach. *EclinMed.* 2023;62:102145. doi: [10.1016/j.eclinm.2023.102145](https://doi.org/10.1016/j.eclinm.2023.102145).

- [43] Schmachtenberg T, Königs G, Dragaqina A, et al. "There is no one who helps you with it": experiences of people with long COVID regarding medical care, therapeutic measures, and barriers in the German healthcare system: results of a qualitative study with four focus groups. *BMC Health Serv Res.* 2023;23(1):1160. doi: [10.1186/s12913-023-10170-x](https://doi.org/10.1186/s12913-023-10170-x).
- [44] Smondack P, Gravier FE, Prieur G, et al. Physiotherapy and COVID-19. From intensive care unit to home care-an overview of international guidelines. *Rev Mal Respir.* 2020;37(10):811–822.
- [45] Siso-Almirall A, Brito-Zeron P, Conangla Ferrin L, et al. Long Covid-19: proposed primary care clinical guidelines for diagnosis and disease management. *Int J Environ Res Public Health.* 2021; 18(8):4350.
- [46] Brode WM, Melamed E. A practical framework for Long COVID treatment in primary care. *Life Sci.* 2024;354:122977. doi: [10.1016/j.lfs.2024.122977](https://doi.org/10.1016/j.lfs.2024.122977).
- [47] Davis HE, McCorkell L, Vogel JM, et al. Long COVID: major findings, mechanisms and recommendations. *Nat Rev Microbiol.* 2023;21(3):133–146. doi: [10.1038/s41579-022-00846-2](https://doi.org/10.1038/s41579-022-00846-2).
- [48] Rafałowicz B, Wagner L, Rafałowicz J. Long COVID oral cavity symptoms based on selected clinical cases. *Eur J Dent.* 2022; 16(2):458–463. doi: [10.1055/s-0041-1739445](https://doi.org/10.1055/s-0041-1739445).
- [49] Alfaifi A, Sultan AS, Montelongo-Jauregui D, et al. Long-term post-COVID-19 associated oral inflammatory sequelae. *Front Cell Infect Microbiol.* 2022;12:831744. doi: [10.3389/fcimb.2022.831744](https://doi.org/10.3389/fcimb.2022.831744).
- [50] Chakraborty T, Jamal RF, Battineni G, et al. A review of prolonged post-COVID-19 symptoms and their implications on dental management. *Int J Environ Res Public Health.* 2021;18(10):5131.
- [51] Jadali Z, Jalil AT. Long COVID and ophthalmology: new insights into underlying disease mechanisms. *Taiwan J Ophthalmol.* 2022; 12(4):499–500. doi: [10.4103/2211-5056.354536](https://doi.org/10.4103/2211-5056.354536).
- [52] Radke N, Ruamviboonsuk P, Tham CCY, et al. Ophthalmology and COVID-19: long-term surveillance needed. *Asia Pac J Ophthalmol.* 2021;10(6):519–520. doi: [10.1097/APO.0000000000000449](https://doi.org/10.1097/APO.0000000000000449).
- [53] Nasserie T, Hittle M, Goodman SN. Assessment of the frequency and variety of persistent symptoms among patients with COVID-19: a systematic review. *JAMA Netw Open.* 2021;4(5):e2111417. doi: [10.1001/jamanetworkopen.2021.11417](https://doi.org/10.1001/jamanetworkopen.2021.11417).
- [54] Weng J, Li Y, Li J, et al. Gastrointestinal sequelae 90 days after discharge for COVID-19. *Lancet Gastroenterol Hepatol.* 2021;6(5): 344–346. doi: [10.1016/S2468-1253\(21\)00076-5](https://doi.org/10.1016/S2468-1253(21)00076-5).
- [55] Augustin M, Stecher M, Wüstenberg H, et al. 15-Month post-COVID syndrome in outpatients: attributes, risk factors, outcomes, and vaccination status - longitudinal, observational, case-control study. *Front Immunol.* 2023;14:1226622. doi: [10.3389/fimmu.2023.1226622](https://doi.org/10.3389/fimmu.2023.1226622).
- [56] Gandjour A. Long COVID: costs for the German economy and health care and pension system. *BMC Health Serv Res.* 2023;23(1): 641. doi: [10.1186/s12913-023-09601-6](https://doi.org/10.1186/s12913-023-09601-6).
- [57] Ma Y, Deng J, Liu Q, et al. 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. doi: [10.3390/ijerph20021613](https://doi.org/10.3390/ijerph20021613).
- [58] Oran DP, Topol EJ. Prevalence of asymptomatic SARS-CoV-2 infection: a narrative review. *Ann Intern Med.* 2020;173(5):362–367. doi: [10.7326/M20-3012](https://doi.org/10.7326/M20-3012).
- [59] Wang L, Yang W. Higher prevalence of long COVID observed in cancer survivors: insights from a US nationwide survey. *Ann Epidemiol.* 2025;103:30–39. doi: [10.1016/j.annepidem.2025.02.004](https://doi.org/10.1016/j.annepidem.2025.02.004).
- [60] Reme BA, Gjesvik J, Magnusson K. Predictors of the post-COVID condition following mild SARS-CoV-2 infection. *Nat Commun.* 2023;14(1):5839. doi: [10.1038/s41467-023-41541-x](https://doi.org/10.1038/s41467-023-41541-x).