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Pre-pandemic lifestyle patterns and mental health outcomes among people reporting post-acute sequelae of COVID-19: evidence from a Slovenian population-based sample

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Abstract

Background The long-term consequences of COVID-19, or post-acute sequelae of SARS-CoV-2 infection (PASC), represent a major public health concern. Beyond persistent physical symptoms, PASC profoundly affects mental health and daily functioning. Despite growing international evidence, little is known about how pre-pandemic lifestyle patterns shape vulnerability to PASC and how its psychological burden extends beyond distress to deficits in well-being. While national settings may shape prevalence estimates and symptom reporting, this study focuses on group differences within a single country—Slovenia, characterized by universal healthcare, high physical activity, strict containment measures, and low institutional trust.

Methods Data were drawn from a representative sample of working-age Slovenian adults ($N = 3{,}048$), surveyed in early 2023. Participants reported infection history, symptom persistence, pre-pandemic lifestyle patterns, and mental health outcomes. PASC was defined following WHO criteria, with an added requirement of functional impairment. Analyses employed chi-squared tests for categorical variables and ANOVAs for differences across ill-being and well-being indicators.

Results Nearly one-third of infected individuals (29.5%) met PASC criteria. Fatigue, decreased physical performance, and cognitive difficulties were the most prevalent and persistent symptoms, often lasting close to a year. PASC was more common among women, younger adults, those facing financial hardship, and individuals with higher education. Lifestyle patterns showed mixed associations: BMI was unrelated, smoking displayed a paradoxically lower risk, while physical activity reduced infection risk but was modestly linked to greater PASC likelihood post-infection. Crucially, PASC was associated with significantly elevated stress, anxiety, and depression, alongside reduced well-being across all domains.

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Conclusions These findings highlight the enduring burden of PASC and its dual impact on distress and well-being, underscoring the need for integrated, system-level planning that links primary care, rehabilitation, and mental health services to mitigate long-term consequences and support recovery.

Keywords Post-Acute sequelae of COVID-19 (PASC), Lifestyle patterns, Mental health outcomes, Slovenian national study

Introduction

The long-term consequences of COVID-19 have emerged as a major public concern in the aftermath of the global pandemic, with a substantial proportion of people affected by the Post-Acute Sequelae of COVID-19 (PASC) [1]. While research has increasingly focused on the physiological manifestations of PASC, there remains a paucity of research on its psychological impact, its distinction from general pandemic-related distress, and the role of lifestyle factors. Moreover, existing research often relies on general indicators of psychological distress, without considering that mental health encompasses both negative (ill-being) and positive (well-being) dimensions. This conflation limits theoretical clarity and impedes the identification of differential correlates [2]. Addressing this gap requires a dual-outcome approach that treats ill-being and well-being as conceptually distinct yet empirically related constructs [3], particularly in the context of prolonged post-viral syndromes such as PASC.

To provide a comprehensive understanding of PASC, it is important to consider how its prevalence and psychological burden unfold within specific social and healthcare contexts [4]. Slovenia represents an informative case for such investigation. The country combines near-universal healthcare coverage and a dense network of community-based medical services [5] with relatively high levels of physical activity and below-average smoking rates [5]. At the same time, it experienced some of the most stringent containment measures in Europe—including border closures, school shutdowns, and restrictions on movement [5]—and relatively low institutional trust during the pandemic, with only about one quarter of the population expressing confidence in the national government [6, 7]. These intersecting features shaped everyday life during COVID-19 and may inform how people perceive and report persistent symptoms and their psychological consequences [8–10]. Rather than suggesting that associations between lifestyle factors, PASC, and mental health are country-specific, the present study uses this context to interpret the epidemiological and psychosocial patterns observed in the Slovenian working population. Specifically, it examines PASC prevalence across demographic groups, the manifestation of both physical and psychological symptoms, and the role of pre-pandemic lifestyle patterns in shaping its development. It further assesses the mental health consequences of PASC through a dual-outcome approach that distinguishes between ill-being and well-being across individuals with different infection histories.

PASC definition, prevalence, and differences among demographic groups

The World Health Organization (WHO) developed a Delphi diagnostic criterion for PASC [1, 11], defining it as a condition that emerges in individuals with a history of probable or confirmed SARS-CoV-2 infection, typically within three months after disease onset, with symptoms persisting for at least two months and not attributable to an alternative diagnosis. PASC is therefore characterized by long-term impairments across multiple organ systems and psychological symptoms, often leading to significant disruptions in daily functioning and quality of life [12–16], following even mild acute infections [12, 15, 17]. To illustrate—according to the UK Office for National Statistics [18], 79% of individuals self-reporting PASC indicated that their symptoms negatively impacted their daily activities, with approximately 20% [18, 19] experiencing significant limitations in performing everyday tasks.

The exact prevalence of PASC in a given population is subject to significant variation depending on the applied methodologies, the definitions of PASC utilized, and various other factors [20, 21]. For example, WHO [22] has estimated that between 10% and 20% of individuals develop PASC following SARS-CoV-2 infection. Some meta-analyses, however, have reported prevalence rates as high as 57% [23–25] and a study in Slovenia [26] found that approximately 70% of individuals infected with the SARS-CoV-2 virus reported experiencing persistent issues three months post-recovery from their initial infection, with these problems persisting for a minimum of two months. Regardless, caution is needed when interpreting these figures, due to the methodological differences between the studies and the absence of consensus regarding the minimum number of symptoms, their severity, or level of functional impairment required to fulfill the diagnostic criteria for PASC [21, 27].

Several studies suggest that the *working-age population* is disproportionately affected by PASC [e.g., [28]], with the highest prevalence observed among individuals aged 35–69 [18, 29–31]. Although not the most physiologically vulnerable group, working-age adults may face greater exposure to infection due to occupational and social demands [32], and may be more attuned to the functional

impairments associated with PASC [33, 34], which could lead to increased symptom recognition and reporting. However, evidence on the relationship between age and PASC is mixed. Some studies report complex associations, potentially influenced by lifestyle, healthcare access, and age-related comorbidities such as cognitive impairment [4, 21]. A large-scale study published in Nature Medicine [35], involving over 380,000 SARS-CoV-2–positive individuals, found that after adjusting for demographic and clinical covariates (including sex, ethnicity, SES, BMI, smoking, pre-existing conditions, and prior symptoms), younger adults (18–30) emerged as the group at greatest risk.

Moreover, studies consistently indicate a higher prevalence of PASC among *women* [18, 23, 25, 30, 35–37], with hormonal factors (such as virus-induced dysfunction of estradiol and other ovarian hormones) potentially contributing to this disparity by prolonging a hyperinflammatory state during the acute phase of COVID-19 and into the post-recovery phase [36, 38]. In addition to biological mechanisms, gender differences in healthcare-seeking behavior and symptom reporting as well as differences in coping strategies may also contribute to the observed disparities. Women typically exhibit greater healthcare-seeking behavior and are more likely to report their symptoms, whereas lower healthcare utilization in men may result in underreporting [39]. Furthermore, *socioeconomic status (SES)* has been demonstrated to play a significant role, with financial hardship correlating positively with the prevalence of PASC [40, 41] and its symptom burden [34], indicating that the highest risk of prolonged recovery from COVID-19 is observed among individuals from the most deprived socio-economic populations. Individuals in such vulnerable circumstances may encounter difficulties accessing adequate care, often due to limited access to healthcare or the financial constraints imposed by the cost of care [41]. Finally, higher *educational attainment* has also been associated with both a lower prevalence of PASC [42, 43] and a reduced intensity of self-reported symptoms [44]. One proposed mechanism is health literacy, which tends to be higher among more educated individuals and is linked to preventive behaviors such as vaccination, mask-wearing, timely healthcare utilization, and effective symptom recognition and management [45–48].

Most common symptoms and duration

The symptoms associated with PASC encompass a wide range of health concerns, affecting multiple bodily systems (respiratory, cardiovascular, gastrointestinal, endocrine, neurological, etc.). Their prevalence varies considerably across studies, depending on design, assessment timing and methods, and the characteristics of the population studied (hospitalized, non-hospitalized, or mixed). Nevertheless, fatigue consistently emerges as one of the most frequently reported symptoms [24, 49–51]. Other commonly observed symptoms include cognitive impairments [49–51], joint pain [51], and shortness of breath or difficulty breathing [24, 50, 51], followed by sleep disturbances [24, 49, 51] and cough. Less frequently reported, yet still notable, are loss of sense of taste [24], impaired usual activity [24], diarrhea [51], loss of smell [24], and muscle pain [24]. These symptoms often co-occur in clusters [e.g., [51–53]] and may change in intensity or presentation over time [21, 54].

In addition to their prevalence, a defining characteristic of PASC symptoms is their persistence. Many people experience multiple symptoms that persist over an extended period. Patients self-report a median of 8 symptoms (ranging from 0 to 33), with an average duration of 12 months (ranging from 1 to 20 months) [55], but the symptoms can also extend beyond this timeframe. For instance, a report by the UK Office for National Statistics [56] revealed that among individuals who self-reported PASC, 71% had experienced symptoms for at least 1 year, 51% for at least 2 years, and 31% for at least 3 years.

Lifestyle factors contributing to PASC

Beyond the abundance of symptoms associated with PASC, several lifestyle factors have been identified as potential risk factors influencing its development and severity. These factors include body mass index (BMI), smoking, and physical activity (PA). Several studies and meta-analyses found *obesity (BMI ≥ 30)* to be a significant factor associated with PASC [25, 57–61]. A 2022 study [35] indicated that individuals with a BMI exceeding 30 kg/m^2 exhibit a 10% increased risk of persistent symptoms relative to those with a BMI in the normal range of 18.5–25 kg/m^2. This could be attributed to elevated levels of systemic inflammation observed among those with higher BMI, which originates from the perivascular adipose tissue that contributes to the release of local and systemic adipokines and cytokines, which may play a role in prolonged immune dysregulation seen in PASC [59, 60].

Moreover, research consistently links *smoking* to the occurrence of PASC [35, 61–64]. The potential mechanisms by which smoking contributes to PASC include immune dysregulation and its established role in endothelial dysfunction. Additionally, the systemic inflammation induced by smoking has the potential to exacerbate the long-term repercussions of SARS-CoV-2 infection [64].

Finally, current body of literature suggests that regular *physical activity* prior to a positive diagnosis of SARS-CoV-2 is associated with reduced risk of developing PASC [65, 66]. Individuals who engaged in a minimum of 150 min of exercise per week were found to be less likely

to report PASC symptoms [67, 68]. Physical activity protects against PASC by improving cardiorespiratory fitness, helping to reduce systemic symptoms like fatigue. Additionally, it supports brain health by increasing neurotrophic factors and anti-inflammatory cytokines, which may alleviate neurological issues [67].

Mental health and mental illness in PASC

The COVID-19 pandemic and its associated public health interventions have had a widespread negative impact on mental health, affecting individuals who never contracted the virus, those who had COVID-19 without developing PASC, and those with PASC [e.g., [69–71]]. This underscores the necessity for a comprehensive comparative approach to mental health of different populations, comprising two distinct yet interconnected aspects – subjective well-being and mental health problems or ill-being [3]. While subjective well-being reflects the equilibrium of positive affective, social, and psychological functioning, mental health problems indicate conditions that disrupt individuals' functioning [72]. It is important to note, however, that the absence of mental health problems does not equate to high subjective well-being, as individuals can lack positive psychological resources despite being disorder-free [73]. Given the complex psychological burden of PASC, addressing both dimensions separately is essential for a more complete understanding of its mental health consequences.

There is some evidence that individuals with PASC experience significantly higher levels of mental health problems than both the general population and those who recovered from the virus without persistent symptoms [14, 74, 75]. A recent meta-analysis estimates depression and anxiety to be among the most profound psychological burdens in PASC patients [76]. Consistent with these findings, other studies reported anxiety prevalence ranging from 16% to 22% and depression from 18% to 21% [16, 77, 78]. The mechanisms underlying these mental health outcomes in PASC remain unclear. While mental health problems may be a direct consequence of the central nervous system involvement and persistent inflammation caused by SARS-CoV-2 infection, they may also arise as a psychological response to prolonged illness and functional impairment, as seen in other chronic diseases, where persistent symptoms contribute to mental health deterioration. Comparable patterns of depression and cognitive symptoms have been observed in other post-infectious conditions, such as pneumonia and stroke, suggesting a broader phenomenon of mental health effects following severe illness [78], possibly driven by the increased psychological distress due to coping with persistent symptoms, changes in quality of life or uncertainty about recovery [74, 78–80]. Supporting this, studies have indicated a strong association between PASC and psychological distress [81, 82].

In addition to the aforementioned mental health challenges faced by individuals with PASC, their overall well-being is significantly impaired [e.g., [2, 83, 84]]. These individuals report diminished affective well-being, including elevated levels of low mood, sadness, dissatisfaction, frustration, anxiety about the future, and fear of reinfection [2, 81, 84]. On a social level, individuals with protracted symptomatology may experience reduced social participation, particularly in work and leisure activities, leading to social withdrawal, feelings of loneliness, and isolation. They may also feel misunderstood or unaccepted due to a lack of awareness or support from others [2, 81, 85]. Furthermore, PASC can affect psychological well-being, with individuals describing a profound disruption to their sense of self, often feeling as though their former identity no longer aligns with their current lived experience of illness. This loss of biographical continuity is accompanied by frustration with their limited ability to manage daily life and family responsibilities, lower relationship quality, reduced personal independence, and a diminished sense of purpose in life [2, 85, 86]. This observed well-being impairment in PASC patients compared to others is likely driven by chronic stress from persistent symptoms and functional limitations, compounded by the psychological burden of uncertainty about recovery and fear of reinfection. Moreover, reduced social support, anguish about the future, and a sense of loss of life coherence contribute to a heightened sense of isolation, and higher disconnection from self, exacerbating emotional distress and lowering the quality of life of individuals with PASC [2, 84, 86].

Purpose of the study and research questions

Due to the multifaceted nature of PASC described above, understanding its epidemiology and identifying contributing factors is essential for managing its long-term health impacts. Although research on PASC has expanded, its manifestations and risk factors may differ across populations due to variation in demographic characteristics, socioeconomic conditions, healthcare access, and lifestyle factors. Consequently, population-based studies remain vital for identifying patterns of vulnerability and informing prevention and rehabilitation strategies [4]. Against this background, the present study examines the epidemiology and psychological consequences of PASC in a large, population-based sample representative of the Slovenian working population.

Slovenia offers a suitable setting for such investigation, combining universal healthcare coverage, relatively high physical activity levels, and low smoking prevalence [5]. During the pandemic, the country implemented strict containment measures—extensive school

closures, movement restrictions, and widespread shifts to remote work [5]—and showed below-average institutional trust compared to other European countries [6, 7], which may have shaped how PASC and its psychological consequences were experienced and reported [9]. We do not advance country-specific hypotheses about the associations between lifestyle factors and PASC or between PASC and mental health; rather, we situate our single-country estimates in their empirical context to aid interpretation of prevalence and symptom reporting. The survey was conducted in January 2023, roughly six months after the lifting of pandemic restrictions, providing a snapshot of early post-pandemic adjustment.

In this context, the study investigates PASC prevalence and symptomatology, the role of pre-pandemic lifestyle behaviors, and the differential impact of PASC on both well-being and ill-being indicators. An overview of the study's main research questions is presented in Fig. 1, which illustrates the conceptual structure of the study components. The specific research questions addressed by this study are:

- Prevalence of PASC: What is the self-reported prevalence of PASC in the Slovenian working population? Are there any differences in prevalence among demographic groups based on sex, age, education, and financial hardship?
- Symptomatology of PASC: What are the most common symptoms reported by people with PASC, and what is the average duration of each symptom?
- Pre-pandemic lifestyle factors: How do pre-pandemic lifestyle patterns (body mass index, smoking, and physical activity) differ among individuals with PASC, those who never had COVID-19, and those who had COVID-19 but did not develop PASC?
- Mental health outcomes: How do mental health outcomes, including indicators of well-being and ill-being, differ among individuals with PASC, those who never had COVID-19, and those who had COVID-19 but did not develop PASC?

Materials and methods

Participants and procedure

The survey was conducted online by an outsourced survey agency using non-probability quota sampling. The sampling method included two sex categories, six age categories, and twelve statistical regions to recruit participants from the agency's online survey panel. The panel consisted of individuals who had provided informed consent to participate in online surveys in exchange for a small compensation. Data collection was conducted between January and February 2023. Reminders were sent to panelists in quota cells with insufficient

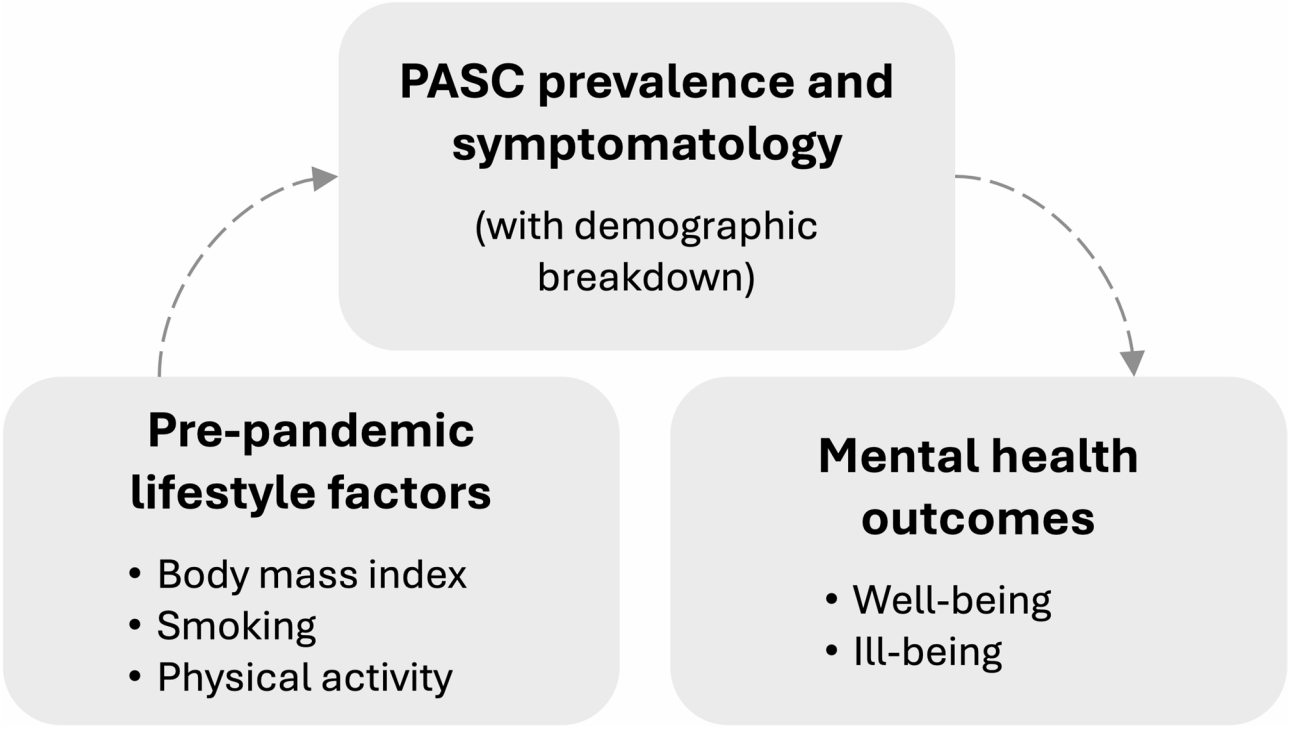

Fig. 1 The main research questions addressed in the present study. Note: Arrows are used solely to depict the conceptual flow between study components and do not represent causal relationships, hypothesized paths, or the analytical model tested in the study

responses, with a particular focus on younger age groups, which have lower participation rates.

Following validity checks, 20 surveys were excluded based on speedster criteria, resulting in a final sample of 3,048 participants aged 18–65, for a response rate of 33.2%. To ensure representativeness, data were weighted using iterative proportional fitting to match respondents to population benchmarks. These demographic benchmarks, including sex, age, education, and statistical region, were obtained from the SiStat Data Portal (SURS, 2022). Table 1 shows a detailed sample breakdown by self-reported gender, age, and education. It is important to note that two participants (0.1%) selected "other" for the gender question. These participants were excluded from the analyses using gender as a variable.

The study was approved by the Ethics Committee of the University of Ljubljana, Faculty of Arts (approval number 306–2023).

Measurement instruments

The survey for this study included items measuring demographic characteristics, recovery from COVID-19 and PASC, pre-pandemic healthy lifestyle patterns, current ill-being and well-being, and other constructs not included in this study.

Demographic characteristics

Participants reported their gender (male, female, other), age in years, and education level. Education was assessed with a single item asking participants to indicate their highest completed level of formal education. Response options followed the national classification of education levels in Slovenia, ranging from incomplete primary school to doctoral degree. For analytical purposes, responses were dichotomized into secondary or lower (primary, vocational, and secondary education) and university or higher (higher professional, university, master's, or doctoral degrees). Participants also assessed their financial hardship by answering the question "*How much difficulty do you have paying all your financial obligations throughout the month?*" on a scale from 1 (*I have no difficulty paying all my obligations and still have some savings*) to 7 (*I cannot make my monthly payments*). Responses to this question were dichotomized to reflect low (1–3) vs. high (4–7) financial hardship.

Items associated with COVID-19 and PASC

Participants were surveyed to determine their history of SARS-CoV-2 infection and the presence of any long-term health issues following infection. Initially, participants were asked whether they had ever been infected with the SARS-CoV-2 virus (*Yes/No*). For those who reported having been infected, a follow-up question asked them to identify any new health problems that emerged after their recovery from COVID-19, which were not present before their infection. Participants could select multiple symptoms from a provided list and add other, non-listed symptoms, which were, if relevant, assigned to a specific symptom category. Participants were then asked to specify the onset and duration of each new symptom by indicating the month and year when the symptom first appeared and when it ceased. To assess the impact of these symptoms on daily life, participants rated the extent to which these health problems limited their everyday activities compared to their pre-COVID-19 condition. This was measured on a 7-point scale ranging from 1 (*no limitations*, *functioning as before*) to 7 (*severe limitations*, *significantly impaired functioning*).

Based on the responses, participants were categorized as having PASC if they met the following criteria: (a)

Table 1 Demographic characteristics for the total sample and segregated by the three PASC status groups

	Total		Non-infected		Infected, no PASC		PASC		Chi-Square test		Effect size
Characterstic	**UnW No.**	**W %**	**UnW No.**	**W Row %**	**UnW No.**	**W Row %**	**UnW No.**	**W Row %**	**χ2 (df)**	***p***	**Cramer's *V***
Total	3048	100.0	847	29.6	1251	40.9	948	29.5			
Gender									44.90 (2)	< 0.001	0.12
Female (1)	1607	47.4	399	26.5	623	38.2	585	$35.3_{(2)}$			
Male (2)	1439	52.6	448	$32.4_{(1)}$	628	$43.4_{(1)}$	363	24.2			
Age									86.43 (4)	< 0.001	0.12
18–29 years (1)	535	18.5	123	23.3	225	$42.7_{(3)}$	187	$34.0_{(3)}$			
30–45 years (2)	1135	36.7	242	22.9	551	$47.7_{(3)}$	342	29.4			
46–65 years (3)	1378	44.7	483	$37.8_{(1,2)}$	476	34.6	419	27.6			
Education									16.37 (2)	< 0.001	0.07
Secondary or lower (1)	1572	77.0	498	$31.4_{(2)}$	618	40.1	456	28.4			
University or higher (2)	1476	23.0	350	23.6	634	43.5	492	$32.8_{(1)}$			
Financial hardship									13.33 (2)	0.001	0.07
Low hardship (1)	1868	56.7	495	28.5	824	$43.7_{(2)}$	549	27.8			
High hardship (2)	1180	43.3	353	31.2	428	37.2	399	$31.6_{(1)}$			

Note: UnW No. = unweighted number, W (Row) % = weighted (row) percentage. Post-hoc tests with Benjamini-Hochberg correction: For each significant pair, the key of the category with the smaller proportion appears as a subscript in the category with the larger proportion

they reported being infected with SARS-CoV-2, (b) they experienced at least one new symptom that appeared within three months after recovery from the infection, (c) these symptoms persisted for more than two months, and (d) participants reported experiencing at least some limitations in daily life due to these symptoms, scoring between 2 and 7 on the limitation scale. While the first three criteria were determined following the WHO definition of PASC (Soriano et al., 2022; WHO, 2021), the last criterion concerning limitations in daily life was an additional criterion based on the need to capture the functional impact of these symptoms on participants' everyday activities.

Pre-pandemic lifestyle patterns

Participants were asked to report their height (without shoes) and their weight (without clothes and shoes) just before the outbreak of the COVID-19 pandemic. From these responses, body mass index (BMI) was calculated using the formula: weight in kilograms divided by the square of height in meters. Participants were then categorized into three BMI groups: *Underweight & healthy weight* (BMI < 25), *Overweight* (BMI 25–29.9.9), and *Obesity* (BMI ≥ 30). Due to a very small number of participants in the *Underweight* category, this group was combined with the *Healthy Weight* category.

Participants were also asked about their smoking habits. They reported whether they had never smoked, had quit smoking (with a distinction between those who quit less than 15 years ago and those who quit more than 15 years ago), or currently smoked (distinguishing between occasional and regular smokers). For analysis, responses were grouped into two categories: non-smokers (including those who never smoked and those who quit) and current smokers (including both occasional and regular smokers).

Finally, participants were asked about their physical activity levels before the pandemic. They indicated whether they were physically active for at least 30 min daily or at least 150 min per week, considering activities at work, during daily chores, and in leisure time – in line with guidelines recommended by the World Health Organization (WHO *global recommendations on physical activity for health*, 2010; WHO *guidelines on physical activity and sedentary behaviour*, 2020). The response options were *Yes* or *No*.

Indicators of Ill-Being

The Perceived Stress Scale (PSS; Cohen & Williamson, 1988) was used as a measure of how stressful participants perceived their life situations to be over the past 30 days. This 10-item scale uses a 5-point rating system ranging from *never* to *very often*. The PSS has demonstrated strong internal consistency, test-retest reliability, and criterion validity (Lee, 2012).

The Patient Health Questionnaire Depression Scale (PHQ-8; Kroenke et al., 2009) was used to assess the severity of depressive symptoms. This scale consists of eight items that correspond to the criteria for depressive disorders as outlined in the DSM-5 (American Psychiatric Association, 2013). Respondents rated the frequency of experiencing each depressive symptom over the past 30 days on a four-point scale ranging from *not at all* to *almost every day*. The scale's good reliability and unidimensional structure have been confirmed across countries (Arias de la Torre et al., 2023).

The Generalized Anxiety Disorder-7 (GAD-7; Spitzer et al., 2006) was used to assess the severity of generalized anxiety symptoms over the past 30 days. This scale consists of seven items, rated on a 4-point scale ranging from *not at all* to *almost every day*. The GAD-7 has demonstrated good reliability and strong validity in distinguishing generalized anxiety from depression (Spitzer et al., 2006).

Indicators of Well-Being

The short form of the Mental Health Continuum (MHC-SF; Keyes, 2002) was used as a self-report instrument to assess subjective well-being. This measure includes 14 items that assess subjective emotional (3 items; i.e., *During the past month, how often did you feel happy?*), social (5 items; i.e., *During the past month, how often did you feel that people are basically good?*), and psychological well-being (6 items; i.e., *During the past month, how often did you feel that your life has a sense of direction or meaning to it?*). Participants rated these items on a 6-point scale ranging from 0 (*never*) to 5 (*every day*), with instructions setting the time frame to the last 30 days. The scale has demonstrated good internal consistency, satisfactory test-retest reliability, and strong construct, convergent, and divergent validity (Lamers et al., 2010).

Data analysis

Data analysis was performed in R [87] and the survey package version 4.4-2 [88]. Data was weighed in the analysis. The analysis began by examining the prevalence of PASC across the entire sample and stratified by demographic characteristics. Participants were categorized into three PASC status groups: (a) those who reported not being infected with SARS-CoV-2 (*non-infected*), (b) those who had COVID-19 but did not develop PASC (*infected, no PASC*), and (c) those who had PASC (*PASC*). Chi-squared tests were used to explore the associations between PASC status and demographic characteristics (sex, age, education, and financial hardship). Cramer's V was calculated as a measure of the effect size. Post-hoc comparisons were performed for pairs of demographic

categories (e.g., male vs. female) within each PASC status and adjusted for multiple comparisons using the Benjamini-Hochberg correction.

For the subsample of participants with PASC, the prevalence and mean duration of specific PASC symptoms were calculated.

The association between PASC status and pre-pandemic lifestyle variables (BMI, smoking, and physical activity) was also examined using chi-squared tests, with Cramer's V as a measure of the effect size. Post-hoc comparisons for pairs of PASC statuses (e.g., *infected, no PASC* vs. *PASC*) were conducted and adjusted for multiple comparisons using the Benjamini-Hochberg correction.

Finally, the three PASC status groups were compared on indicators of ill-being (perceived stress, depression, generalized anxiety) and well-being (emotional, social, and psychological well-being) using ANOVA. Eta-squared values and their 95% confidence intervals were calculated to measure the effect size. The significance of differences between pairs of group means was assessed using Tukey's HSD post-hoc tests.

Results

PASC prevalence in the total sample and by demographic characteristics

In the total sample, 29.6% of participants reported never having been infected with SARS-CoV-2, while 70.4% had been infected with SARS-CoV-19 at least once. A total of 29.5% of participants reported experiencing at least one long-term health problem that began within three months after recovery from COVID-19, lasted at least two months, and had a debilitating effect on their lives. These participants were categorized as participants with PASC.

We observed significant associations between PASC status and demographic variables, although the effect sizes were weak. As shown in Table 1, the prevalence of PASC was higher among women than men. Conversely, a larger proportion of men reported either not being infected or being infected without developing PASC. Among emerging adults (ages 18–29), the prevalence of PASC was higher than in other age groups. PASC was also more prevalent among individuals with a higher level of education compared to those with a lower level. Lastly, the prevalence of PASC was higher among those reporting high financial hardship than among those with low financial hardship.

Table 2 Specific health problems reported by participants with PASC ($n = 948$) and their average duration

	UnW No.	W %	Duration (months)	
Symptom			***M***	***SD***
Fatigue, lack of energy	720	75.7	8.8	9.1
Decreased physical performance	611	64.5	7.9	8.5
Muscle and joint pain	456	48.9	6.7	8.1
Difficulty concentrating, remembering	379	38.7	10.7	9.7
Sleep disturbances	346	37.6	10.1	9.9
Chest pain, shortness of breath	319	33.9	6.8	8.9
Cough	327	33.8	6.0	8.3
Headache	313	33.6	8.2	9.6
Problems with taste, smell perception	273	29.7	5.7	7.9
Heart palpitations, rhythm disturbances	256	27.3	8.0	9.3
Unpleasant feelings of fear, sadness, anger, weepiness, negative thoughts	242	26.6	8.8	10.0
Digestive problems	143	16.0	7.4	8.5
Other problems	69	6.1	10.6	9.8
Menstrual or ejaculation problems	51	5.5	9.9	9.4

Note: *UnW No.* Unweighted number, *W %* Weighted percentage

PASC symptoms and their average duration

Table 2 presents the most commonly reported PASC symptoms in our sample and their average duration. Fatigue and lack of energy were the most frequently reported symptoms, affecting over three-quarters of participants with PASC. This was followed by decreased physical performance, reported by approximately two thirds of participants, and muscle and joint pain, reported by nearly half. The symptoms with the longest average duration were difficulty concentrating or remembering, difficulty sleeping, and menstrual or ejaculatory problems, each lasting approximately or more than 10 months on average.

Unhealthy pre-pandemic lifestyle patterns and PASC status

We also examined the association between PASC status and pre-pandemic lifestyle patterns, as presented in Table 3. While no significant association was found between PASC status and BMI, significant associations were observed with smoking and physical activity, albeit with small effect sizes. Specifically, the proportion of non-smokers was lowest among *non-infected* group. Additionally, the proportion of individuals meeting the WHO recommendations for sufficient physical activity was lowest in the *infected, no PASC* group.

Mental health indicators and PASC status

Table 4 presents the comparisons among the three PASC status groups across various indicators of ill-being and well-being. ANOVA revealed significant differences among the groups for all indicators, with effect sizes ranging from small to medium [89], the largest being for depression and generalized anxiety. Specifically, the *PASC* group exhibited the highest levels of perceived stress, depressive symptoms, and anxiety symptoms. Conversely, this group reported the lowest levels of emotional, social, and psychological well-being.

Table 3 The association between the PASC status and pre-pandemic lifestyle variables (BMI, smoking, physical activity)

	Total		Non-infected (A)		Infected, no PASC (B)		PASC (C)		Chi-Square test		Effect size
Variable	**UnW No.**	**W %**	**UnW No.**	**W Col. %**	**UnW No.**	**W Col. %**	**UnW No.**	**W Col. %**	**χ^2 (df)**	***p***	**Cramer's *V***
Body mass index (BMI)									3.08 (4)	0.544	0.023
Underweight & healthy weight	1315	41.5	352	39.8	564	42.9	399	41.4			
Overweight	1012	33.6	289	35.0	407	33.3	316	32.6			
Obesity	689	24.8	196	25.2	265	23.7	228	25.9			
Smoking									15.79 (2)	< 0.001	0.072
Non-smoker	2173	68.1	558	63.0	926	$70.6_{(A)}$	689	$69.8_{(A)}$			
Occasional or regular smoker	875	31.9	290	$37.0_{(B, C)}$	326	29.4	259	30.2			
Physical activity									12.50 (2)	0.002	0.064
Sufficient	2431	80.4	704	$82.9_{(B)}$	962	77.4	765	$82.1_{(B)}$			
Insufficient	617	19.6	144	17.1	290	$22.6_{(A, C)}$	183	17.9			

Note: UnW No. Unweighted number, *W (Col.) %* Weighted (column) percentage. Post-hoc tests with Benjamini-Hochberg correction: For each significant pair, the key of the category with the smaller proportion appears as a subscript in the category with the larger proportion

Differences between the latter two groups were small and inconsistent.

Discussion

The present study contributes to the growing body of research on Post-Acute Sequelae of COVID-19 (PASC) by examining its prevalence, symptomatology, and the role of pre-pandemic lifestyle factors in a representative sample of the Slovenian working population. It also provides additional insight into the mental health consequences of PASC by distinguishing between indicators of ill-being and well-being, which is consistent with contemporary conceptualizations of mental health as a multidimensional construct encompassing both the absence of distress and the presence of positive psychological functioning [3].

Prevalence and symptomatology of PASC

Our results indicate that nearly one-third (29.5%) of individuals who had contracted SARS-CoV-2 met the criteria for PASC. This figure aligns with the prevalence rates reported in previous studies, which range from 10% to 57% [22–25], but is lower than in a previous study conducted in Slovenia, which reported approximately 70% of individuals experienced persistent issues three months post-recovery [26]. This discrepancy may stem from differences in PASC definitions and methodological approaches. Specifically, our study classified individuals as having PASC only if the newly emerged symptoms had at least some impact on their functionality, whereas the previous study did not require this criterion for individuals to be categorized as having PASC. Consequently, their broader definition of PASC likely resulted in a higher prevalence estimate, potentially including individuals with mild persistent symptoms that were not captured in the present study. While our findings reinforce the notion that persistent post-COVID symptoms are a widespread phenomenon that transcends geographical boundaries, the heterogeneity in reported prevalence rates across studies highlights the methodological challenges associated with defining and assessing PASC. Nontheless, our stricter definition may provide a more accurate representation of the functionally impairing burden of PASC in the working population.

Symptom-wise, fatigue and decreased physical performance emerged as the most commonly reported complaints, affecting 76% and 65% of PASC participants, respectively. These findings align with previous research emphasizing fatigue as a hallmark feature of PASC [24, 49–51] and are consistent with national data from National Institute of Public Health of the Republic of Slovenia [26], which identified fatigue or lack of energy and reduced physical capacity as the most frequently reported long-term issue. Furthermore, other prevalent symptoms included muscle and joint pain, cognitive impairments (difficulty concentrating or remembering), and sleep disturbances, which were also identified as frequently occurring in previous epidemiological studies [24, 49–51]. The persistence of these symptoms over extended periods—averaging more than ten months for cognitive and sleep-related impairments—suggests that PASC represents a significant and prolonged health burden for affected individuals. This aligns with prior evidence indicating that a substantial proportion of individuals report long-term functional limitations even a year or more after initial infection [14, 24, 56], highlighting the chronic nature of PASC-related impairments and the need for ongoing clinical and public health interventions. Taken together, these findings suggest that PASC is not merely a transient post-viral condition but a chronic health issue

Table 4 Comparison in ill-being and well-being indicators between the three PASC status groups

Indicator	Total		Non-infected (A)		Infected, no PASC (B)		PASC (C)		ANOVA		Effect size	Post-hoc (Turkey's HSD test)
		SD	*M*	*SD*	*M*	*SD*	*M*	*SD*	F(df)	*p*	η^2 [95% CI]	
Perceived stress	25.6	7.2	24.7	6.8	24.4	6.7	28.2	7.5	88.80(2)	< 0.001	0.055 [0.040, 0.071]	A, B < C
Depression	14.2	5.5	13.7	5.4	12.9	4.8	16.6	5.7	13.59(2)	< 0.001	0.082 [0.064, 0.101]	B < A < C
Generalized anxiety	12.4	5.0	11.9	4.8	11.2	4.4	14.5	5.4	12.48(2)	< 0.001	0.076 [0.059, 0.094]	B < A < C
Emotional well-being	11.9	3.9	12.2	3.9	12.4	3.9	11.0	3.8	37.73(2)	< 0.001	0.024 [0.014, 0.039]	A, B > C
Psychological well-being	24.7	7.6	25.4	7.5	25.0	7.8	23.4	7.3	16.66(2)	< 0.001	0.011 [0.004, 0.019]	A, B > C
Social well-being	15.6	6.6	15.9	6.8	16.0	6.6	14.7	6.2	11.37(2)	< 0.001	0.007 [0.002, 0.014]	A, B > C

with far-reaching implications for individuals' daily functioning, work capacity, and long-term healthcare needs.

Notably, our findings indicate that psychological and cognitive symptoms, such as difficulties with concentration, memory, and sleep disturbances, tend to persist the longest. Previous studies have also shown that neurocognitive symptoms often persist longer than physical ones, with difficulties in concentration and memory, as well as sleep disorders frequently reported during the initial 12 months following infection and remaining among the most prevalent symptoms even beyond two years [90, 91]. This underscores the substantial impact of PASC on mental and cognitive health, potentially affecting daily functioning, work performance, and overall quality of life, which aligns with previous research highlighting the prolonged burden of neuropsychiatric symptoms in PASC patients [16, 78]. Given the prolonged duration of cognitive and psychological symptoms, targeted strategies such as cognitive rehabilitation programs and mental health support should be considered to mitigate the long-term effects on individuals' well-being and functional recovery. It is also possible that the persistent fatigue and overall illness burden increase individuals' sensitivity to cognitive disruptions, making such symptoms more salient and distressing over time.

The co-occurrence of multiple symptoms in PASC highlights its complexity as a multifaceted syndrome with potentially overlapping pathophysiological mechanisms. For instance, the combination of fatigue, cognitive impairment, and sleep disturbances resembles the symptomatology of chronic fatigue syndrome (CFS) and other post-viral syndromes, which have been identified as potential analogs of PASC [79]. Although we did not perform formal cluster analysis, the frequent co-occurrence of these symptoms suggests the need for further research to determine whether PASC constitutes a novel condition or shares underlying mechanisms with other post-infectious syndromes, as has been proposed in previous work on post-viral fatigue conditions [79, 92].

Demographic differences in PASC prevalence

Our findings reveal significant demographic disparities in PASC prevalence, with higher rates observed among women (35.3%) compared to men (24.2%). This gender disparity is well-documented in the literature [18, 23, 25, 30, 35–37] and may be attributable to a combination of biological and social factors. Hormonal influences, particularly virus-induced estradiol dysregulation, have been proposed as a potential mechanism, as disrupted regulation may prolong inflammation [25, 38]. Differences in healthcare-seeking behavior and symptom reporting may also play a role, with women generally more inclined to seek medical attention and report symptoms, whereas

men's lower healthcare utilization may lead to underreporting and underdiagnosis [39].

Within the working-age population, we observed evident age-related differences in PASC prevalence, with the highest rate reported in young adults (18–29 years). Several factors may explain this trend. First, younger individuals may have experienced higher exposure risks due to greater occupational and social mobility, consistent with prior research linking workplace exposure to heightened PASC risk [32]. Additionally, younger adults may be more likely to notice and report persistent symptoms due to greater functional expectations for physical and cognitive performance in daily life [33, 34]. It is also possible that variations in immune response and post-viral recovery across different age groups within the working-age population play a role. Specifically, younger adults tend to exhibit a more robust inflammatory response to COVID-19 [93], which may lead to prolonged immune dysregulation and contribute to lingering symptoms. In contrast, older adults experience immunosenescence, potentially dampening excessive inflammation [94] and reducing the likelihood of persistent immune-related symptoms. However, further research is needed to explore this hypothesis.

In addition to gender and age, our study suggests that individuals experiencing financial hardship exhibit a higher prevalence of PASC, aligning with previous research that highlights the strong association between socioeconomic factors and PASC prevalence [40, 41]. These findings support existing evidence that individuals from socioeconomically disadvantaged backgrounds face a disproportionate burden of PASC-related impairments, likely due to a combination of healthcare access barriers, occupational exposures, baseline health disparities and lifestyle factors such as reliance on public transportation and residence in densely populated or multigenerational households [34, 41]. This assertion, however, should be explored further with data linking indicators of health and economic status.

Contrary to previous research linking higher educational attainment to lower prevalence and reduced severity of PASC symptoms [42–44], our results suggest the opposite trend. Individuals with post-secondary education reported a higher prevalence of PASC than those with lower education levels. While higher health literacy, often associated with greater education, may promote preventive behaviors and reduce infection-related risks [45], it may also enhance individuals' ability to detect and articulate persistent symptoms once they occur, leading to more frequent reporting of PASC. Additionally, individuals with higher education may face greater cognitive demands in their work, making them more sensitive to subtle declines in functioning and thus more likely to recognize and report such changes [95].

Pre-pandemic lifestyle factors and PASC risk

While several prior studies have identified obesity as a risk factor of PASC [60, 61], our study did not find a significant association between body mass index (BMI) and PASC status. One possible explanation for this discrepancy is differences in study design, the use of self-reported versus clinically measured BMI, or the presence of unmeasured confounders such as comorbidities. These factors may have contributed to the attenuation of the expected association, calling for further research using a comprehensive and objective set of variables.

While we observed significant associations of PASC status with smoking and physical activity levels, the results of post-hoc analyses were not entirely aligned with our expectations. The proportion of non-smokers was the lowest among those who had not been infected with SARS-CoV-2, but no difference was observed related to PASC. Although previous studies have suggested that smoking may increase vulnerability to severe COVID-19 outcomes and long-term complications [62, 64], our findings do not support a direct relationship between smoking and the development of PASC. It is conceivable that smokers may be less likely to notice or report certain symptoms, either due to a normalization of chronic somatic complaints or lower expectations regarding health status. Notably, some research has indicated a potentially reduced susceptibility to initial SARS-CoV-2 infection among current smokers, a counterintuitive finding, termed the 'smoker's paradox' [e.g., [96]]. One proposed explanation is that nicotine may modulate the expression of entry receptors or influence the inflammatory response [97]. These inconsistencies in the literature underscore the necessity for cautious interpretation of findings. Methodological differences, particularly in the selection of diagnostic measures (PCR, serological testing, self-report), and the possible influence of altered antibody responses in smokers on infection detection [98] likely contribute to the heterogeneity of results.

Furthermore, individuals in the 'infected, no PASC' group were significantly less likely to meet WHO recommendations for physical activity compared to the 'non-infected' and 'PASC' groups and had the highest proportion of insufficiently active individuals. Among individuals who were infected, those who had engaged in at least 30 min of daily physical activity prior to the pandemic had a slightly higher likelihood of developing PASC, whereas those who were not sufficiently active were less likely to develop PASC. This suggests that while physical activity was associated with a reduced probability of infection, it did not provide protection against the development of PASC and may have even been linked to a slightly increased risk among those who contracted COVID-19. This aligns with previous research indicating that physical activity supports immune function and may

reduce susceptibility to infections, though its role in post-viral recovery remains unclear [66, 99]. Some studies have suggested that regular exercise may mitigate the risk of persistent post-COVID symptoms [65–67], but our findings do not support this claim. We believe there are two explanations for this discrepancy. First, high levels of physical activity prior to infection may enhance the reactivity of the immune system, thereby reducing the risk of infection [100]. At the same time, it could also amplify the immune response upon infection, increasing the risk of immune dysregulation and persistent symptoms. Additionally, strenuous exercise during or after infection might also prolong recovery by exacerbating systemic inflammation [101]. On the other hand, however, physically active individuals may be more attuned to changes in their bodies and decreased functionality/physical abilities [102] and thus possibly more likely to notice and report ongoing symptoms in self-report surveys.

Mental health implications of PASC

Consistent with prior research [76, 78], our results show that individuals with PASC report significantly higher levels of stress, depression, and anxiety compared to those without persistent symptoms. These psychological difficulties may be intensified by the prolonged, unpredictable nature of PASC symptoms, which can contribute to frustration, hopelessness, and a diminished sense of control over one's health [52, 79]. The effect sizes for these associations were moderate to large, underscoring the substantial psychological burden imposed by PASC.

Importantly, mean levels of depression and generalized anxiety were elevated across all subgroups relative to pre-pandemic population norms. This pattern aligns with recent European evidence indicating increased post-pandemic symptom levels in the general population [103]. It suggests that the pandemic itself—through prolonged uncertainty, containment measures, and disruptions to everyday life—has exerted a lasting imprint on mental health, irrespective of infection status. While group differences emphasize the additional burden among individuals with PASC, the overall elevation across groups reflects the broader psychosocial toll of the pandemic period.

Crucially, our study goes beyond addressing ill-being alone by simultaneously examining subjective well-being as a distinct yet interrelated dimension of mental health [3]. Accordingly, in addition to elevated distress levels, our study also revealed significantly lower well-being among PASC individuals. These individuals reported significantly lower scores in emotional, social, and psychological well-being domains. Our findings thus suggest that the impact of PASC extends beyond clinical mental health symptoms and also diminishes individuals' positive affective, social, and psychological resources, affecting life satisfaction, interpersonal relationships, sense of purpose, and daily functioning. The observed well-being deficits likely stem from multiple factors, including prolonged symptom distress, reduced social participation, and uncertainty about recovery [2, 86]. Additionally, stigma and a lack of understanding about PASC in medical and social contexts may contribute to feelings of isolation and frustration, further worsening mental health outcomes [86].

The distinction between ill-being and well-being is particularly important in the context of long-term post-viral recovery, where the dual burden of higher ill-being and lower well-being indicates that PASC affects both mental health components. This underscores the need for holistic interventions addressing both distress reduction and well-being enhancement in PASC management. Integrating psychological support alongside medical treatment could improve overall recovery outcomes and enhance quality of life for individuals with PASC [14, 55]. The stronger effects observed for ill-being likely reflect the closer conceptual and experiential link between PASC symptomatology and negative affective states. PASC involves chronic physical symptoms—such as fatigue, pain, and cognitive difficulties—that are inherently distressing and overlap with depressive and anxiety features. By contrast, well-being reflects broader cognitive and social evaluations of one's life and functioning, which may be partially preserved despite physical and emotional strain.

The role of national context in understanding PASC

The present study offers valuable insights into the prevalence, symptomatology, and psychological consequences of PASC in the Slovenian working population, recognizing that PASC is not only a medical phenomenon but one embedded within broader structural, social, and cultural contexts [4]. Accordingly, observed similarities and differences from previous studies should be understood in light of contextual influences that may shape both the reporting and experience of symptoms, rather than as evidence of distinct underlying mechanisms.

Slovenia provides near-universal health coverage and maintains a relatively dense primary care network [5]. This system may facilitate access to healthcare and the recognition of persistent symptoms, particularly among working-age adults, while also mitigating socioeconomic disparities in care. Conversely, system limitations, such as long waiting times, workforce shortages, and restricted hospital capacity, may hinder timely diagnosis and adequate treatment [5]. Because the present study relied on self-reports rather than clinical diagnoses, these barriers likely had limited direct impact but may have contributed to the relatively conservative prevalence estimate (29.5%) compared with international reports exceeding 50% [23].

Contextual stressors specific to Slovenia may also have amplified the psychological burden of PASC. The country enacted some of the strictest containment measures in Europe, including full lockdowns, prolonged school closures, and restrictions on movement [5]. Alongside relatively low levels of institutional trust [9, 10], these conditions likely contributed to heightened uncertainty and reduced perceived support, adding to the distress experienced by individuals with persistent symptoms. The chronic nature of PASC, coupled with long-term social isolation and disrupted life trajectories, likely eroded individuals' capacity for positive psychological functioning rather than merely increased distress. Broader socio-cultural factors, such as collective value orientations and justice beliefs, may further shape how individuals experience and report prolonged symptoms, particularly in contexts characterized by low institutional trust. Cross-national findings support this view, showing that such value systems influence public health behaviors and pandemic outcomes [104, 105].

Lifestyle patterns may further help contextualize these findings. Slovenia is characterized by above-average physical activity levels and strong tobacco-control policies [5]. In our study, physically active individuals were less likely to become infected but slightly more likely to develop PASC if infected. This pattern may reflect both physiological and perceptual mechanisms—such as greater immune or inflammatory reactivity to infection, higher interoceptive awareness, or increased sensitivity to changes in physical performance among active individuals. These effects could appear more salient in populations with high baseline activity levels. Likewise, the observed "smoker's paradox" suggests that PASC can also develop among individuals who generally lead healthier lifestyles, pointing to the relevance of other determinants—environmental, structural, or biological—that may influence vulnerability even among non-smokers [97].

Study limitations, future directions, and clinical implications

While this study provides valuable insights into the epidemiology, risk factors, and mental health implications of PASC, several methodological limitations should be acknowledged. First, the use of self-reported data may have introduced recall bias, particularly in the retrospective assessment of symptoms and pre-pandemic lifestyle factors. It is possible that individuals suffering from PASC, whose symptoms often include fatigue and reduced physical capacity, overestimated their prior levels of physical activity when comparing them to their current state. Such contrast effects could have contributed to some of the observed differences between groups. In addition, response biases may have arisen from varying thresholds for evaluating the severity and functional impact of symptoms across participants. Second, the cross-sectional nature of the study limits the ability to draw conclusions about temporal or causal relationships. Third, although the sample is representative of the working-age population in Slovenia, it does not include individuals potentially at higher risk of prolonged symptoms, such as older adults or those with severe pre-existing health conditions. Finally, the possibility of residual confounding, especially due to unmeasured factors such as variations in healthcare access or pre-pandemic health status, cannot be ruled out.

While these limitations should be considered, our findings underscore the importance of systematic monitoring of physical and mental health in the aftermath of COVID-19 to identify and support individuals at risk of PASC. Establishing long-term follow-up and psychosocial assessment frameworks would not only facilitate timely care in Slovenia but also contribute valuable comparative data to the broader international evidence base. Future research should aim to clarify the underlying mechanisms of PASC and inform clinical practice. Registry-based studies could laverage existing healthcare data to provide longitudinal insights into recovery trajectories, healthcare utilization, or return-to-work patterns among individuals with documented PASC symptoms. Moreover, studies incorporating biomarkers and neuroimaging techniques may help elucidate the biological underpinnings of PASC and distinguish it from other post-viral syndromes.

Both research and clinical initiatives should prioritize personalized, multidisciplinary treatment approaches that address the physiological and psychological components of PASC. Based on the symptom patterns observed in our study, interventions targeting fatigue, persistent inflammation, and immune dysregulation, alongside psychological therapies addressing distress, quality of life, and cognitive difficulties, should be systematically evaluated in clinical trials. Findings from such trials could inform the development of flexible, individualized rehabilitation programs. To support long-term care, these efforts should be complemented by digital health monitoring tools and close collaboration between primary care providers, specialists, and mental health professionals to ensure integrated, patient-centered care for individuals affected by PASC.

Conclusion

While the acute phase of the pandemic has ended, many individuals continue to experience long-term health consequences. This study provides important insights into the epidemiology, symptomatology, and mental health impact of PASC in a representative working-age Slovenian sample. Our findings highlight the substantial

burden of PASC, particularly in terms of persistent fatigue and cognitive impairments. By assessing both ill-being and well-being, we capture a broader picture of mental health, consistent with the dual continua model, which posits that the absence of mental illness does not necessarily imply the presence of positive mental health. This approach is valuable for identifying not only the presence of psychological distress but also potential deficits in positive functioning that may warrant intervention.

The observed associations between demographic factors, lifestyle characteristics, and PASC underscore the complex interplay of biological, social, and behavioral determinants in shaping post-COVID health outcomes. These insights call for integrated healthcare approaches that address both the physical and psychological dimensions of PASC. Furthermore, our findings highlight the importance of considering the national context to understand how structural and behavioral factors can shape the experience and reporting of PASC symptoms, rather than the associations themselves.

While large-scale public health interventions may no longer be necessary, lessons from PASC research can inform the management of other post-viral and chronic conditions triggered by infections. Further reserach should focus on identifying factors that facilitate recovery and on evaluating effective, multidimensional intervention strategies. Healthcare providers should have access to evidence-based guidelines that support individualized, integrated care and symptom management for those who continue to experience persistent post-COVID effects.

Abbreviations

PASC Post-Acute Sequelae of COVID-19
CFS chronic fatigue syndrome

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Authors' contributions

GZK and KB led the conceptualization of the study. GZK conducted the statistical analyses, and was primarily responsible for interpreting the results and drafting the manuscript. JV and JM contributed to the development of the introduction and background sections. All authors contributed to the study design, provided critical revisions, and approved the final version of the manuscript.

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Data availability

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Ethics Committee of the University of Ljubljana, Faculty of Arts (approval number 306–2023). All participants were members of an online survey panel and had provided prior informed consent to participate in research studies conducted by the survey agency. The study was carried out in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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