Prevalence, risk factors, and impact of long COVID in a socially vulnerable community in Brazil: a prospective cohort study

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Summary

Background Long COVID is an emerging global public health issue. Socially vulnerable communities in low- and-middle-income countries were severely impacted by the pandemic and are underrepresented in research. This prospective study aimed to determine the prevalence of long COVID, its impact on health, and associated risk factors in one such community in Rio de Janeiro, Brazil.

Methods A total of 710 individuals aged 18 and older, with confirmed SARS-CoV-2 infection at least three months prior, were enrolled between November 25, 2021, and May 5, 2022. Participants were assessed via telephone or in person using a standardized questionnaire to evaluate their perception of recovery, symptoms, quality of life, and functional status.

Findings Twenty percent of participants did not feel fully recovered, 22% experienced new or persistent symptoms, 26% had worsened functional status, 18% had increased dyspnoea, and 32% reported a worse quality of life. Persistent symptoms included headache, cough, fatigue, muscle pain, and shortness of breath. Dyspnoea during the acute phase was the strongest independent predictor of worsening outcomes. Females and individuals with comorbidities were more likely to report worse recovery, functioning, dyspnoea, and quality of life.

Interpretation Our findings reveal a high burden of severe and persistent physical and mental health sequelae in a socially vulnerable community following COVID-19.

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Keywords: Long COVID; Post-acute COVID-19 syndrome; Post-covid condition; Social vulnerability; Risk factors

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Research in context

Evidence before this study

We searched PubMed for studies on Long COVID from January 1, 2020, to October 1, 2023. Our main search terms were "Long COVID", "Post-COVID-19 condition", "Long haul COVID", "COVID sequelae" and "persistent symptoms". We refined our search to focus on studies related to socially vulnerable populations using combinations of the following terms: "Vulnerable Populations" [Mesh], "Socioeconomic Factors" [Mesh], "Poverty Areas" [Mesh], "Urban Health" [Mesh], "Health Disparities" [Mesh], "Urban Health" [Mesh], "Poverty", "Favela" "Slum", "Informal Settlement", "Socially vulnerable", "Economically vulnerable", "Marginalized Populations", "Social Marginalization", "Low-Income country", "Low-and-middle income country". We did not find any studies specifically characterizing the burden of long COVID in urban slum areas in South America. This underscores the urgent need for studies focused on such communities, which were disproportionally affected by the COVID-19 pandemic.

Added value of this study

This study offers insights on the long-term effects of COVID-19 in a South American cohort. It adds value by focusing on a non-hospitalized population within a socially vulnerable community. To our knowledge this is the first study to use an internationally standardized protocol to assess long COVID in such a context. We gained a comprehensive understanding of the prevalence, symptoms, and impact on quality of life associated with this condition. Our findings indicate that a significant percentage of individuals continue to experience symptoms and functional decline after the acute phase of COVID-19. Notably we found that dyspnea during the acute illness was a strong predictor for long term complications. Additionally, our study suggests that full vaccination may provide protection against persistent COVID-19 symptoms.

Implications of all the available evidence

The results of our study, along with the limited data available from low- and middle-income countries (LMICs) underscore the importance of strategies for addressing long COVID in these settings. It is crucial to have research infrastructure, follow up of patients and diverse populations included in therapeutic trials. This study reinforces the need for customized public health policies and healthcare interventions in poor areas from LMICs to minimize the impact of COVID. Moreover, it highlights the significance of vaccination programs within these communities. In summary the evidence strongly indicates that global collaboration in research and healthcare delivery is essential to ensure that LMICs are not left behind during the recovery phase of the COVID-19 pandemic.

Introduction

The COVID-19 pandemic has led to multiple long-term consequences that are still not fully understood. These consequences range from significant economic and social effects to profound impacts on survivors' physical and mental health. While most individuals will recover from the initial infection within a few weeks, some continue to experience persistent and often debilitating symptoms for extended periods. This new syndrome, termed "Long COVID" or "Post-COVID-19 condition", is recognised as an emerging global public health problem by the World Health Organization and national health authorities.[1–3]

There is still debate about the diagnostic criteria, risk factors, pathophysiological mechanisms, and syndromic classification of long COVID. A recent systematic review revealed that approximately four months after infection, 45% of individuals who recovered from acute COVID-19, continued to suffer from various persistent symptoms.[4] An international consensus study has identified a comprehensive range of outcomes associated with long COVID. These outcomes include symptoms induced by exertion, fatigue, and pain, as well as conditions involving the cardiovascular, respiratory, and nervous systems, along with cognitive, mental health, and physical well-being.[5] Large-scale studies have uncovered several risk factors for long COVID, including female sex, obesity, comorbidities, hospitalisation for acute COVID-19, socioeconomic vulnerability, and belonging to an ethnic minority.[6,7] Furthermore, a recent meta-analysis has found that complete COVID-19 vaccination reduces the likelihood of developing long COVID symptoms.[8]

While research on long COVID continues to expand, there are several gaps from underrepresented populations to support the current knowledge on the field. The prevalence of this condition, the frequency of symptoms, and its impact on quality of life, especially in more vulnerable communities, remains to be determined and are crucial information for planning future care services and public health policies.

The pandemic had a disproportionate impact on poor communities and fragile healthcare systems. A systematic review including COVID-19 data from 25 low- and middle-income countries (LMICs) indicated that age-specific infection fatality rates in these countries were approximately twice as high as those in high-income nations.[9] At the beginning of 2023, Brazil had reported over 700,000 COVID-19 deaths and 37 million cases, although these figures are probably underestimated.[10] In Brazil, approximately 15% of the urban population lives in "favelas" (slums), densely populated areas with substandard housing, rendering them particularly vulnerable to the impact of epidemics.[11] These communities often face significant health

disparities due to a range of factors, such as poverty, housing insecurity, and limited access to essential public services. For example, a study conducted in Buenos Aires, Argentina, revealed that slum inhabitants hospitalised for acute COVID-19 were significantly younger and had more than double the risk of death compared to individuals living outside slums.[12]

Studies characterising the long COVID syndrome have predominantly been conducted in high-income countries (HIC). However, the burden of long COVID in low- and middle-income countries (LMICs) remains insufficiently explored, and to our knowledge, no studies have yet focused specifically on slum populations.[4,13,14] To address this gap, we established a cohort of SARS-CoV-2 PCR-positive patients from *Complexo da Maré*, a complex of 16 slums in Rio de Janeiro, Brazil.[15] Our study had three primary objectives: First, to determine the prevalence of long COVID in the community. Second, to measure the impact of Long COVID in the quality of life and daily functioning of affected individuals. Last, to identify the risk factors associated with the development of Long COVID. To achieve these objectives, we applied a standardised survey developed as part of a harmonised global protocol.[16] The primary outcome was the self-perception of recovery, and the secondary outcomes were the presence of new or persisting symptoms, quality of life, functional status, and dyspnoea on daily activities. By gaining insight into the burden of long COVID in settings that are often underrepresented in medical research, we can more effectively prioritize specific groups for healthcare interventions and allocate resources with greater efficiency.

Methods

Study design and settings

This was a community-based prospective cohort study in *Complexo da Maré*, Rio de Janeiro, Brazil, established in November 2021 during the Vacina Maré vaccination program.[17] It is also part of a global study to assess the long-term health consequences of COVID-19 in different populations, in collaboration with the International Severe Acute Respiratory and Emerging Infection Consortium (ISARIC).[16] Ethical approval was obtained from the National Research Ethics Committee (IRB/CONEP) (CAEE: 49726921.6.0000.5248 and 44180821.1.0000.5249).

Complexo da Maré is the largest socially vulnerable community in the municipality with more than 140.000 inhabitants dispersed over a 4.3 km^2 territory and a Human Development Index (HDI) of 0.686, ranked the 123rd lowest HDI out of 126 neighbourhoods in Rio de Janeiro. During the COVID-19 pandemic, this community became the focus of several initiatives jointly organised by academia (FIOCRUZ) and a local non-governmental organisation (Redes da Maré) with the support of the public and private sectors.[17] One of these initiatives was the Vacina Maré vaccination campaign in the Maré Cohort project. This cohort study aims to evaluate the impact of the COVID-19 pandemic on Maré residents, including assessments of clinical and epidemiological profiles, vaccine effectiveness, and long-term health impacts.[18,19]

Following the cohort's objective, this study described and evaluated the Long COVID-19 seroprevalence and impact in a vulnerable community, Complexo da Maré.

Participants

All adult permanent residents (18 years or older) of Complexo da Maré, who were alive at least 90 days after a positive SARS-CoV-2 RT-PCR result, were eligible for this study. Attempts were made to contact all 2815 participants meeting these criteria, resulting in successful contact with 1593 individuals. Of these, 756 agreed to participate, and 710 were ultimately included in the analysis (Supplementary Figure S1). All participants were already enrolled in the Maré Cohort study and completed an Informed Consent (IC) form before enrolment.[17] No incentives were offered to encourage participation. Between November 25th, 2021, and May 5th, 2022 the participants were assessed by a trained researcher via either a phone call or in-person from November 2021, using the standardised ISARIC Tier 1 follow-up case report form (CRF) developed by the ISARIC global COVID-19 working group described previously.[16] The assessment was conducted in a single interview. A translated, culturally adapted version of the CRF was applied once per participant. Data from participants' responses were entered into a locally hosted Research Electronic Capture (REDcap) database.

Variables

The ISARIC Tier 1 follow-up CRF gather data on a broad range of variables including, acute stage symptoms, self-perception of recovery and new or persisting symptoms and validated tools to measure breathlessness on daily activities, functioning and quality of life. The self-perception of recovery was a question with five mutually exclusive choices: "Strongly disagree", "disagree", "neither disagree nor agree", "agree" or "strongly agree". The recovery measure was developed and piloted for the assessment of COVID-19 patients following Consensus-based Standards for the Selection of Health Measurement Instruments (COSMIN)/Core Outcome Measures in Effectiveness Trials (COMET) guidelines.[5,20] New or persisting symptoms were collected as dichotomous (yes/no) variables. The Medical Research Council (MRC) dyspnoea scale measures the degree of breathlessness on daily activities in a scale ranging from 1 (no dyspnoea except on strenuous exercise) to 5 Too breathless to leave the house, or breathless when dressing or undressing).[21] The WG-SS The Washington Disability Group (WG-SS) is a tool assessing functioning in six dimensions: seeing,

hearing, walking, or climbing steps, remembering or concentrating, self-care, and communication. Each domain has 4 levels: no difficulty, some difficulty, a lot of difficulty, or cannot be done at all.[22] The overall internal consistency of this instrument was confirmed with a Cronbach's alpha of 0.83. The EuroQol®EQ-5D-5L tool measures the quality of life in five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has 5 levels: no problems, slight problems, moderate problems, severe problems, and unable to/extreme problems.[23] The overall internal consistency of this instrument was confirmed with a Cronbach's alpha of 0.82. Baseline patient data on demographic characteristics, comorbidities, hospital admissions and vaccination were obtained in the survey from the Maré cohort and Vacina Maré databases. The Ethnicity labels were adapted from the original CRF to also include the label "Pardo", translated to English as "Brown", which represents individuals that identify with a mixture of two or more options of colour or race. This category is used by the Brazilian Institute of Geography and Statistics (IBGE), the entity responsible for conducting census surveys in Brazil.[24]

Outcomes

Our primary outcome was the self-perception of recovery at ≥90 days after the onset of COVID-19 acute symptoms: We considered not recovered (those with long-term health consequences) the participants that responded "strongly disagree" or "disagree" and recovered otherwise.

Secondary outcomes consisted of the presence of new or persisting symptoms, worsening EQ-5D-5L, WG-SS, or MRC scale scores. In the survey, participants provided self-reported data regarding their condition as they remembered it before the onset of COVID-19 and at the time of the assessment. The levels of each EQ-5D-5L and WG-SS categories were presented both in the original form (levels 1–5 in the EQ-5D-5L and 1–4 in WG-SS) as well as a modified version dichotomized into normal ("no problems", corresponding to level 1 in EQ-5D-5L or "no problems" corresponding to level 1 in WG-SS) and "problems", corresponding to any of the any of the remaining levels.[22,23] The EQ-5D-5L and WG-SS scales were considered if worse if worse in at least one dimension. The EQ-5D-5L and WG-SS instruments demonstrated strong internal consistency, with Cronbach's alpha values of 0.82 and 0.83, respectively. All outcomes were presented as categorical variables.

Statistical analysis

We described participant's characteristics, long-term health information and outcomes using median and interquartile range (IQR) for continuous variables and absolute frequencies and proportions for categorical variables. We evaluated the main new and persisting symptoms. To study the co-occurrence of symptoms, we calculated a correlation matrix using the phi coefficient for each pair of symptoms, amongst patients with recorded presence or absence of both and displayed it with a heatmap. To aid the visualization of symptom groups we used hierarchical clustering with dendrograms, displaying only the statistically significant correlations. We compared the clinical characteristics and demographics of participants between "recovered or unsure" and "not recovered" as a univariable analysis. Differences in groups for categorical variables were assessed with Chi-square test or Fisher's exact test where counts were under five, and with the Wilcoxon rank-sum test for continuous variables. For secondary outcomes, we compared the persistence of symptoms, worsening quality of life and disabilities between pre- and post-COVID-19 acute-phase.

Finally, to estimate the association of participant's characteristics and long COVID-19 outcomes, we applied a multivariable logistic regression. The response variable was the indicator of self-reported recovery. The predictor variables were age, sex, ethnicity, education level, the presence of any comorbidities, vaccination status, and the presence of dyspnoea during the acute stage of COVID-19. Variable selection was performed based on clinical relevance. No interactions were included in the model. We obtained estimates for odds ratio (OR) and their corresponding 95% confidence intervals for each variable. For the sensitivity analysis, we applied the same logistic regression model for each secondary outcome with the response variable after multiple imputation by chained equations (MICE) of missing values. Statistical significance was defined as $p < 0.05$. All analyses were conducted in R (version 4.2.1). This study followed the STROBE guideline recommendations.

Role of the funding sources

The funding sources had no role in the design of the study, the collection, analysis, and interpretation of data, the writing of the manuscript, or the decision to submit the manuscript for publication.

Results

We included 710 participants based on the eligibility criteria outlined in the Methods section. The median time from acute COVID-19 onset to follow-up was 160 days (IQR: 128–229, range 92–790). The sample included mostly females (68%, 486/710) with a median age of 41 years (IQR: 31–53). Most self-identified as having a brown skin colour or ethnicity (50%, 354/710), and 69% (472/688) had completed secondary or post-secondary education respectively. Pre-existing comorbidities were present in 51% (322/630) of participants, with obesity (32%, 191/630), hypertension (20%, 144/710), and diabetes (5.9%, 42/710) being the most common. The vast majority (96%, 671/702) reported having

received complete vaccination against SARS-CoV-2 at the time of the survey. Only 1.3% (9/709) of the participants required hospitalisation during the acute phase of COVID-19 (Table 1 and Supplementary Table S1).

Self-reported recovery

At the time of assessment, 20% (143/706) reported not feeling fully recovered from COVID-19. Notably, this group had a higher medium age and a higher proportion of individuals who were female, had pre-existing comorbidities, lower education levels, required hospitalization and experienced dyspnoea during the acute stage of COVID-19. Among the reported comorbidities, hypertension, diabetes, and obesity were more frequently associated with self-reported non-recovery (Table 1).

Symptoms and health assessments

New or persisting symptoms that were not present prior to their COVID-19 illness onset were reported by 22% (158/710) of participants. Among those, the majority (68%, 109/158) experienced between one and three symptoms (Supplementary Figure S2). The five most frequently reported symptoms among all participants were headache (11%, 77/710), persistent cough (8%, 57/710), fatigue (7%, 52/710), persistent muscle pain (5%, 36/710) and shortness of breath (4%, 31/710) (Fig. 1A). To better understand the relationships between these symptoms, we investigated their correlation and identified two main clusters. Cluster one is characterised by fatigue correlated with most of the musculoskeletal and gastrointestinal symptoms. Cluster two is characterised by headache, respiratory and most sensorial symptoms (Fig. 1B).

Based on the MRC scale, 18% of participants reported new or worsening dyspnoea compared to their pre-COVID baseline. This increase was present for all abnormal levels but was mostly related to MRC levels two (7%, 49/706–16%, 111/706) and three (1%, 9/706–6%, 40/706) (Fig. 2A, Supplementary Table S1). Additionally, 32% of participants had some decline in health-related quality of life. There was an increase in problems related to four out of five dimensions of the EQ-5D-5L instrument: Anxiety and depression (23%, 160/696–32%, 224/696), mobility (7%, 51/696–16%, 108/696), pain/discomfort (14%, 98/696–25%, 173/696), and usual activities (3%, 18/696–7%, 48/696)

	All	Recovery (self-reported)		
	N = 706[a]	Recovered or unsure, N = 563[a]	Not recovered, N = 143[a]	p-value[b]
Age (years)	42 (31, 53)	41 (30, 52)	45 (35, 55)	0.021
Age group (years)				0.11
18–39	312 (44%)	260 (46%)	52 (36%)	
40–59	295 (42%)	227 (40%)	68 (48%)	
60+	99 (14%)	76 (13%)	23 (16%)	
Female sex	482 (68%)	369 (66%)	113 (79%)	0.0020
Skin color or ethnicity				0.55
Brown	353 (50%)	286 (51%)	67 (47%)	
White	198 (28%)	155 (28%)	43 (30%)	
Black	142 (20%)	110 (20%)	32 (22%)	
Other	13 (1.8%)	12 (2.1%)	1 (0.7%)	
Education (N = 684, 97%)				0.0075
Primary or lower	213 (31%)	156 (29%)	57 (40%)	
Secondary or higher	471 (69%)	387 (71%)	84 (60%)	
Comorbidities (N = 627, 89%)				
Any comorbidities	319 (51%)	232 (47%)	87 (66%)	0.0001
Obesity **(N = 586, 83%)**	190 (32%)	139 (30%)	51 (43%)	0.0065
Hypertension	140 (20%)	101 (18%)	39 (27%)	0.012
Diabetes mellitus	42 (5.9%)	25 (4.4%)	17 (12%)	0.00077
Chronic pulmonary disease	23 (3.3%)	15 (2.7%)	8 (5.6%)	0.11
COVID-19 vaccination (N = 698, 99%)				0.22
Complete	667 (96%)	534 (96%)	133 (94%)	
Incomplete or unvaccinated	31 (4.4%)	22 (4.0%)	9 (6.3%)	
Acute COVID-19 hospitalization (N = 705, 99.8%)	9 (1.3%)	4 (0.7%)	5 (3.5%)	0.020
Acute COVID-19 dyspnea	151 (21%)	91 (16%)	60 (42%)	<0.0001

[a]Median (IQR); n (%). [b]Wilcoxon rank sum test; Pearson's Chi-squared test; Fisher's exact test.

Table 1: **Characteristics of the study participants, stratified by the self-reported recovery status.**

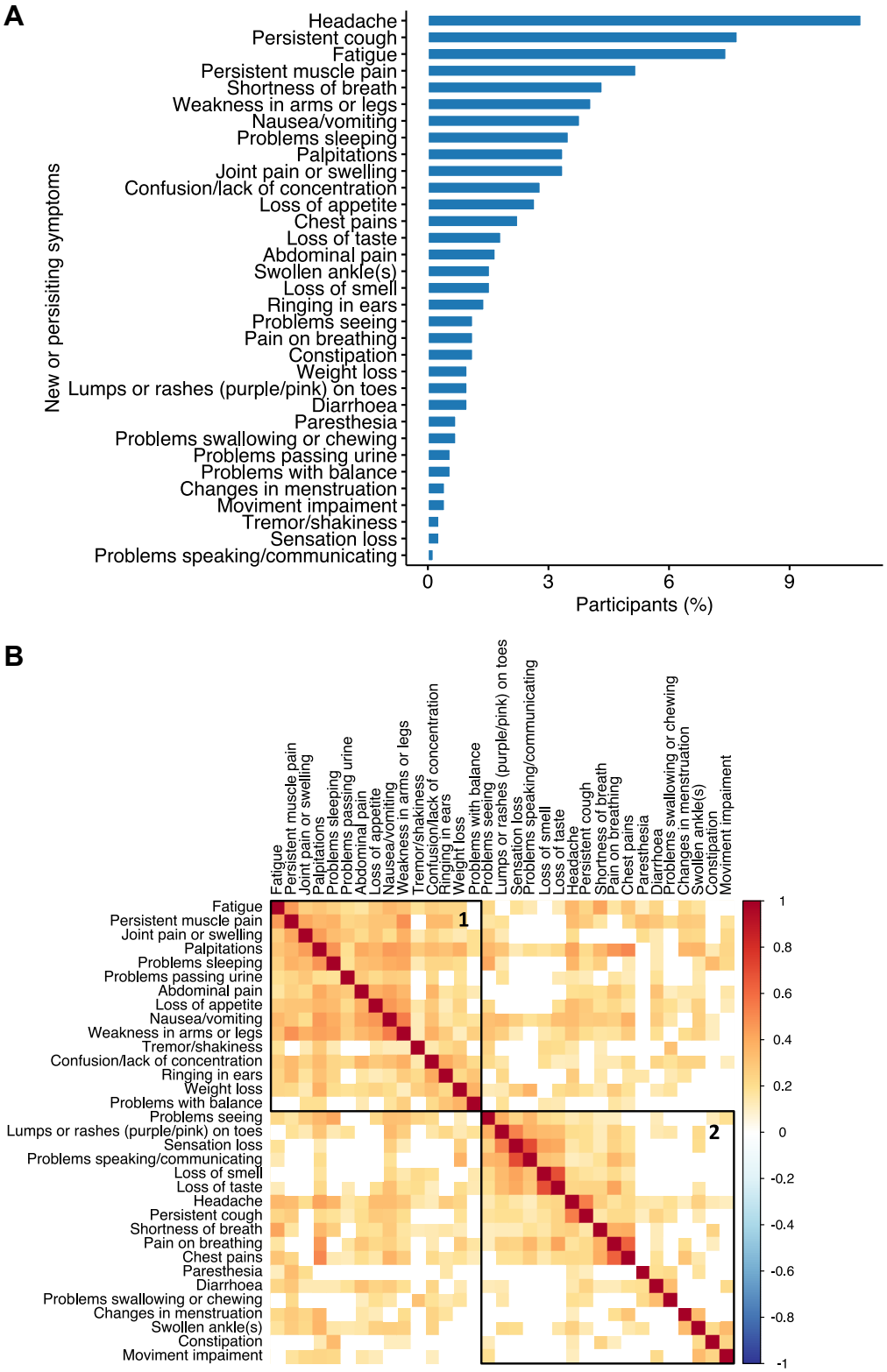

Fig. 1: **New or persisting symptoms.** (A) Percentage of each symptom in relation to the total number of participants for whom pre presence or absence of symptoms was recorded. (B) Correlation between symptoms. The fill color represents the Pearson coefficient for each pair of symptoms. Only significant correlations ($p \leq 0.05$) are represented. The matrix is organized by hierarchical clustering. The black square demarcations indicate the two main clusters.

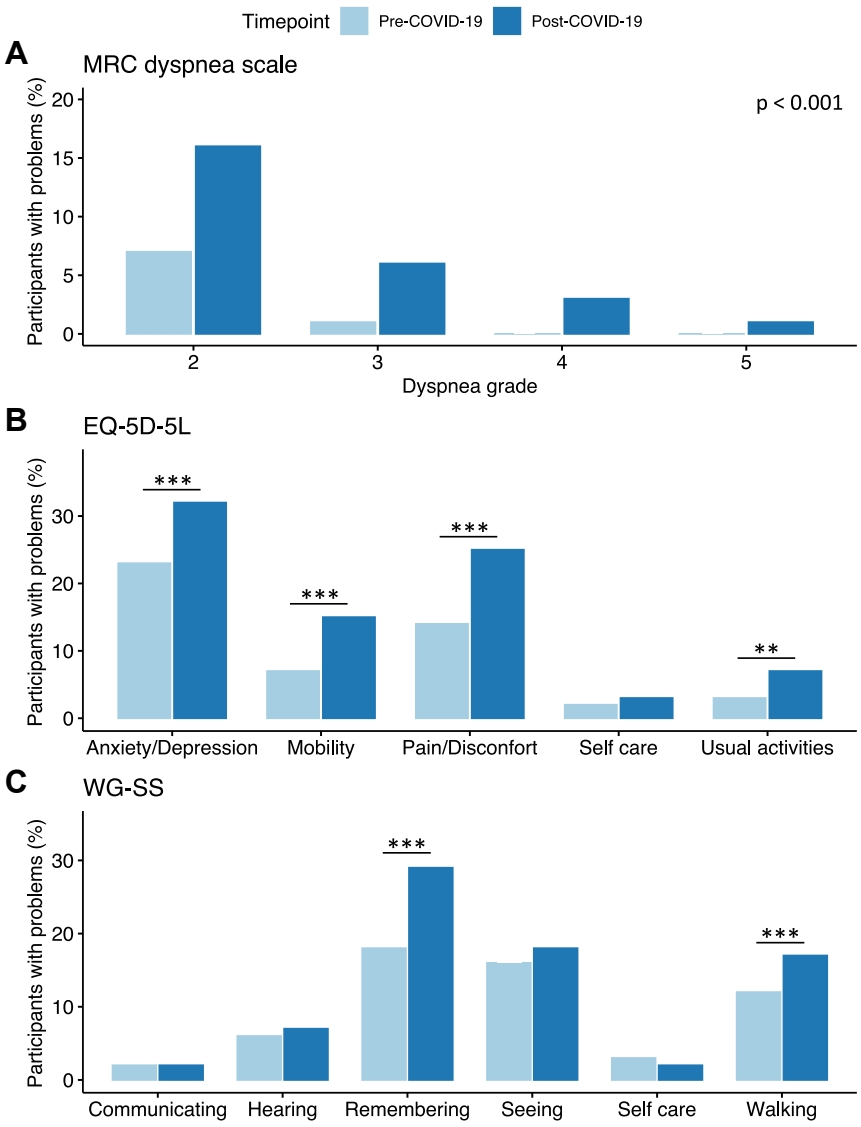

Fig. 2: **Standardized health assessments.** The bars represent the percentages in relation to the total number of participants for whom each instrument was recorded and are grouped as the status before COVID-19 (light blue) and at the time of the survey (dark blue). (A) MRC dyspnea scale. The categories represent the abnormal levels (2–5). (B) EQ-5D-5L. For each dimension, the levels were dichotomized into "no problems" (level 1) and "problems" (levels 2–5). (C) Washington Group Short Set on Functioning (WG-SS). For each domain, the levels were dichotomized into "no problems" (level 1) and "problems" (levels 2–4). The pre-and-post-COVID assessments were tested with the Wilcoxon signed rank test with continuity correction (**: $p \leq 0.01$, ***: $p \leq 0.001$).

(Fig. 2B). Although most problems were slight to moderate, severe to incapacitating anxiety or depression was reported by 6% (40/696) of participants (baseline of 2%. 12/696) (Supplementary Table S2). The WG-SS assessment revealed increased functioning difficulties especially relating to remembering and concentrating (17%, 120/689–29%, 198/689) and walking domains (12%, 81/689–17%, 119/689) (Fig. 2C, Supplementary Table S3). Specifically, the frequency of participants reporting "a lot of difficulty" in remembering and concentrating increased from 3% (20/689) to 6% (45/689). Overall, 26% of participants reported worse functioning status after COVID-19.

Risk factors for long-covid

The multivariable logistic regression models used to analyse risk factors for primary and secondary outcomes were adjusted for age, sex, ethnicity, education level, the presence of any comorbidities, COVID-19 vaccination status and dyspnoea during the acute stage. For the

primary outcome of self-reported recovery, the results showed that females (OR: 2.15, CI: 1.31, 3.64, p = 0.0032), individuals with comorbidities (OR: 1.91, CI: 1.23, 2.99, p = 0.0043), those who had incomplete (number of doses below the recommended scheme) or no vaccination (OR: 3.01, CI: 1.17, 7.34, p = 0.017), and individuals who experienced dyspnoea during the acute stage of COVID-19 (OR: 3.94, CI: 2.53, 6.17. p < 0.0001) had an increased risk of not feeling fully recovered (Fig. 3). We performed a sensitivity analysis using an imputed dataset, with comparable results (Supplementary Figures S3 and S4, Supplementary Table S4).

For the secondary outcomes, we found that females, individuals with comorbidities, and those who were affected by dyspnoea during the acute disease had a higher risk of experiencing worsening dyspnoea (MRC), as well as a poorer health-related quality of life and functioning (WG-SS). Additionally, dyspnoea in the acute phase was associated with an increased risk of new or persisting symptoms (Table 2).

Discussion

Our study reveals the impact of long COVID in a large, socially vulnerable urban community in a middle-income country. *Complexo da Maré*, situated in one of the most populous cities in Brazil, is the largest cluster of slums in the country and was severely impacted by the pandemic. This is one of the first reports on the burden of long COVID in poor communities. In order to ensure accurate results, we only included cases that were confirmed by RT-PCR and came from a well-established longitudinal prospective cohort. Furthermore, this survey adhered to an international harmonised protocol, enabling our results to be comparable across diverse populations from different countries.[16,25–27] Our findings indicate that one in five participants in the favela did not experience a full recovery or reported new or persisting symptoms at 90 or more days post-COVID-19 onset. Additionally, a significant proportion of the participants reported reduced health-related quality of life, functioning difficulties, and dyspnoea upon exertion. We also identified several risk factors for long COVID, including being female, having comorbidities, and experiencing dyspnoea during the acute disease. Being fully vaccinated against COVID-19 provided protection against long-term sequalae compared to having incomplete or no vaccination. This is in line with findings reported in a cohort in Israel.[28]

The prevalence of long COVID in this study falls within the range of previous estimates in non-hospitalized populations, although they have shown considerable variation. For example, according to a pooled analysis of 11 studies, the prevalence of non-hospitalised individuals who had at least one long-term symptom (≥28 days post onset) was 34.5% (95% CI 21.9%–49.7%).[4] The observed heterogeneity between studies may be attributed to the diversity of study designs, varying lengths for monitoring recovery over time, and the lack of consistent procedures for gathering information, as well as differences in study populations. Moreover, the current clinical case definitions for long COVID/Post-Covid condition established by the WHO and national health authorities are broad and may be refined as new evidence becomes available.[1–3] In our study, the cutoff for inclusion was at least 90 days (3 months) from the onset of the initial infection, in line with the WHO definition. Our cohort exhibited a diverse

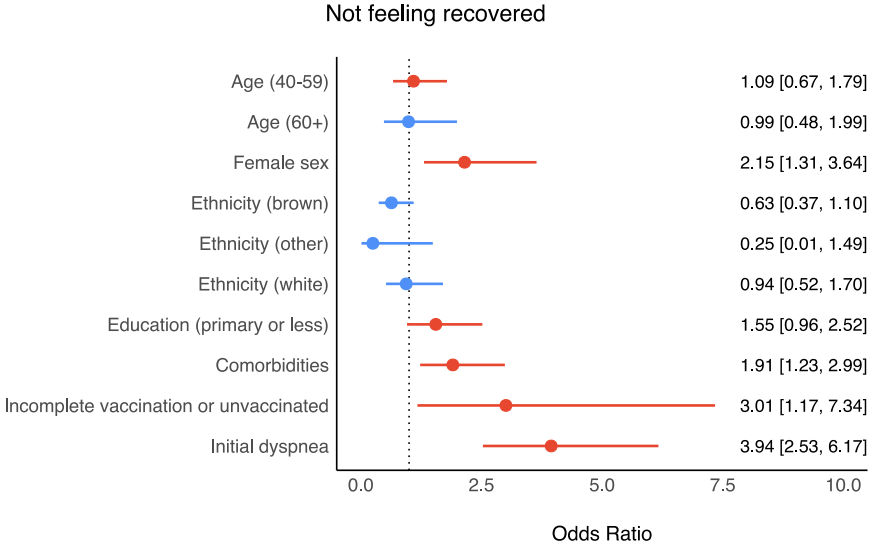

***Fig. 3:* Multivariable logistic regression model to estimate the association between the participants' characteristics and self-reported recovery (primary outcome).** The values represent the odds ratios with the corresponding 95% confidence interval for each variable.

	New or persisting symptoms			Worse dyspnea (MRC)			Worse EQ-5D-5L			Worse WG-SS		
	OR[a]	95% CI[a]	p-value	OR[a]	95% CI[a]	p-value	OR[a]	95% CI[a]	p-value	OR[a]	95% CI[a]	p-value
Age group (years)												
18–39	–	–		–	–		–	–		–	–	
40–59	1.29	0.80, 2.06	0.29	1.56	0.93, 2.62	0.092	1.39	0.91, 2.14	0.13	1.41	0.90, 2.22	0.14
60+	0.48	0.21, 1.03	0.067	0.69	0.30, 1.55	0.38	0.97	0.51, 1.82	0.93	1.19	0.61, 2.27	0.61
Female sex	1.11	0.71, 1.77	0.66	2.14	1.26, 3.76	0.0060	2.46	1.60, 3.83	0.00010	1.57	1.01, 2.46	0.046
Ethnicity												
Black	–	–		–	–		–	–		–	–	
Brown	1.43	0.83, 2.50	0.20	0.98	0.56, 1.76	0.95	0.73	0.45, 1.18	0.19	1.09	0.66, 1.85	0.74
Other	1.38	0.27, 5.52	0.67	0.69	0.09, 3.45	0.68	0.49	0.10, 1.89	0.33	1.52	0.36, 5.54	0.54
White	0.69	0.36, 1.33	0.27	0.68	0.35, 1.33	0.26	0.60	0.35, 1.03	0.064	1.02	0.57, 1.84	0.94
Education												
Secondary or more	–	–		–	–		–	–		–	–	
Primary or less	1.48	0.92, 2.38	0.10	1.25	0.75, 2.07	0.38	1.80	1.17, 2.76	0.0070	1.53	0.98, 2.39	0.061
Any comorbidities	1.24	0.81, 1.90	0.33	2.33	1.45, 3.80	0.00050	1.73	1.18, 2.54	0.0050	1.54	1.03, 2.31	0.037
COVID-19 vaccination												
Complete	–	–		–	–		–	–		–	–	
Incomplete or unvaccinated	2.08	0.83, 4.93	0.10	1.89	0.66, 4.87	0.21	1.66	0.68, 3.93	0.25	1.21	0.44, 3.00	0.69
Initial dyspnea	3.88	2.51, 6.02	<0.0001	5.55	3.52, 8.83	<0.0001	2.65	1.75, 4.03	<0.0001	2.96	1.94, 4.52	<0.0001

[a]OR, Odds Ratio; CI, Confidence Interval.

Table 2: **Multivariable logistic regression model for the association between the participants' characteristics and the secondary outcomes.**

array of symptoms, most commonly headache, persistent cough, and fatigue. These symptoms were also frequently observed in many other non-hospital and hospital-based studies,[4] and were included in a recently developed post-Covid condition core outcome set (COS). The COS aims to provide a framework for harmonizing research.[5]

We identified two distinct clusters of symptoms, with headache commonly associated with respiratory and sensorial symptoms, and fatigue with musculoskeletal and gastrointestinal symptoms. These clusters could be relevant to clinicians in the triage of patients presenting in healthcare centres, allowing for more individualized diagnosis and care based on the subclassification.

Our assessment revealed that one in three participants in our cohort had reduced health-related quality of life following COVID-19. Notably, the observed increase in anxiety and depression aligns with several publications showing mental health and other neurological issues following COVID-19 illness.[13] We also identified an increase in chronic pain, discomfort, and reduced functioning, which have previously been shown to contribute to the deterioration of psychological well-being.[29] It is particularly concerning that the mobility of this population is getting worse, as indicated by both the quality of life and the WG-SS functioning scales. This may cause difficulties accessing public transportation and navigating their local urban environment. Another finding impacting quality of life was increased problems with remembering and concentrating, colloquially referred to as "brain fog." Despite only 4% of participants reporting that they had new or persistent dyspnoea when asked about this directly as part of a list of symptoms, however, when using the MRC dyspnoea scale almost one in five (18%) reported respiratory distress during activities they could previously carry out without problems. This underscores the importance of a more comprehensive evaluation of functional disability caused by dyspnoea, using instruments such as the MRC dyspnoea scale. This approach may offer a better estimate of the resources required for rehabilitation in the community.

The risk factors for long COVID identified in our study align with a recent systematic review and meta-analysis including 41 studies, indicating their generalizability.[30] Notably, the severity of the acute disease remains one of the most reliable predictors of long-term SARS-CoV-2 sequelae. In our cohort, which consisted almost exclusively of non-hospitalized patients, dyspnoea during acute illness served as a surrogate for disease severity and was the strongest predictor of long COVID. We also found that female sex was a strong independent risk factor for worse outcomes. The sexual dimorphism of the immune response has been suggested as a possible factor contributing to the higher incidence of COVID-related sequelae in females.[31] However, our cohort had a greater enrolment of females, which raising the possibility of a reporting bias regarding health among the sexes. Therefore, many biological, societal, and behavioural factors may be at play in explaining this difference, and further

investigation is necessary. In addition, our findings suggest that a lower educational level may correlate with reduced access to healthcare, leading to delayed or inadequate treatment for COVID-19 and potentially exacerbating long COVID severity. Individuals with lower education levels are often in precarious employment, lacking health insurance and paid sick leave, which can affect their recovery process.[32] Furthermore, lower health literacy associated with less education can impair the management of ongoing symptoms and hinder navigation through healthcare services.[33] This was evidenced in our study by the association of lower educational levels with reduced quality of life and functioning, aligning with the outcomes of previous, more extensive population studies.[34]

Poor COVID-19 outcomes have often been associated with older age and comorbidities, likely due to a decline in the body's overall resilience and the inability of the immune system to resolve the acute infection fully.[31] Our cohort is substantially younger than most published studies, representing the age distribution of the Complexo da Maré community. Additionally, our study included individuals who survived the acute disease, potentially contributing to a survival bias toward a younger population. Thus, the relatively low number of older individuals in our cohort may have limited our ability to detect statistically significant effects in this age group. Whether vaccination can reduce the risk of or alleviate the impact of long COVID is a crucial matter for public health. Recent studies in other populations, including a meta-analysis, found that complete vaccination could have favourable effects in this context.[35] In the Maré community, a successful mass vaccination campaign was carried out during the pandemic, resulting in the high proportion of immunised participants observed in our study.[18] Our initial analysis suggested that vaccination was linked to self-perceived full recovery. However, this finding was not replicated in the sensitivity analysis or demonstrated in the secondary outcomes. The limited number of participants with incomplete or no vaccination may have prevented the detection of a statistically significant association.

When evaluating the findings of our study, it is important to consider the limitations. First, the absence of a control group of individuals who did not have COVID-19 and share similar characteristics to our participants may affect the interpretation of our results' specificity. Second, since the survey was only conducted once, we couldn't compare results across multiple assessments, and asking patients to recall outcomes before Covid-19 could have resulted in recall bias. Third, it's possible that symptomatic individuals were more inclined to participate than those without symptoms. This could lead to selection bias, potentially compromising the representativeness of the sample. Fourth, during the follow-up survey, we did not screen participants for SARS-CoV-2, which leaves the possibility that some of them may have been re-infected with Covid-19. Finally, due to our relatively small sample size, this study's analyses should be regarded as exploratory and interpreted in conjunction with the broader literature on long COVID. Despite these limitations we identified a significant proportion of adults that had not fully recovered from COVID-19 three or more months post-onset, experiencing persistent symptoms, new or worsened disabilities impacting on their daily functioning. Considering the young cohort of working age adults in a disadvantaged community this is of concern.

In conclusion, our study provides evidence emphasizing the high burden of long COVID in a socially vulnerable community. By using multiple framings to allow participants to express their recovery status, we gained a deeper understanding of this new and not yet fully comprehended condition. Our findings indicate that many individuals experienced severe and persistent physical and mental health sequelae following COVID-19. We also identified specific clusters and characteristics associated with a higher risk of developing long COVID and a possible protective effect of vaccination. These findings can help to inform the government in allocating adequate public resources to address the specific requirements of these communities which were particularly overwhelmed by the pandemic. Further research is needed on the impact and aetiology of long COVID to guide support strategies aimed at improving long-term outcomes.

Contributors

Conceptualization: FAB, PA, LSLB, OTR, PK, AABS, GVR, CMCD, EPS, LEA, JS, JJS, LS. Data curation: GVR, AABS. Formal analysis (including accessing and verifying the raw data): PA, LSLB, FAB, OTR, PK. Software and visualization: PA. Writing (original draft): PA, FAB, LSLB. Writing (review and editing): PA, FAB, LSLB, OR, LS, JJS, JS. Supervision and final responsibility for the decision to submit for publication: FAB.

Data sharing statement

Data can be provided by the corresponding author upon reasonable request.

Declaration of interests

The authors declare they have no competing interests.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2024.100839.

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