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Article

Long COVID at Low and High Altitude: A Countrywide Epidemiological Analysis of Self-Reported Long-Term Persisting Symptoms in Ecuador

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Abstract: Background: Some patients who have recovered from COVID-19 have experienced a range of persistent symptoms or the appearance of new ones after a SARS-CoV-2 infection. These symptoms can last from weeks to months, impacting everyday functioning to a significant number of patients. Methods: A cross-sectional analysis based on an online, self-reporting questionnaire was conducted in Ecuador from April to July 2022. Participants were invited by social media, radio, and TV to voluntarily participate in our study. A total of 2103 surveys were included in this study. We compared socio-demographic variables and long-term persisting symptoms at low (< 2,500 m) and high altitude (>2,500 m).Results: Overall, 1100 (52.3%) responders claimed to have long-term symptoms after SARS-CoV-2 infection. Most of these symptoms were reported by women (64.0%), the most affected group was young adults (68.5%), and the majority of long-haulers were mestizos (91.6%). We found that high altitude residents were more likely to report persisting symptoms (71.7%) versus those living at lower altitudes (29.3%). The most common symptoms were fatigue or tiredness (8.4%), hair loss (5.1%) and difficulty concentrating (5.0%). The highest proportion of persisting symptoms was observed among those who received an incomplete vaccine scheme. Conclusions: This is the first study describing post-COVID symptoms' persistence in low and high-altitude residents. Our findings demonstrate that women, especially those aging between 20-40, are more likely to describe sequalae associated with post-COVID. We also found that living at a high altitude was associated with earlier onset and longer symptom duration. Finally, we found a greater risk to report long lasting symptoms among women, those with previous comorbidities and those who had a severer acute SARS-CoV-2 infection.

Keywords: COVID-19; SARS-CoV-2; long-COVID; sequalae; symptoms; Latin America; high altitude

1. Introduction

COVID-19 irrupted into our lives in a very rapid way after the SARS-CoV-2 virus jumped from animals housed and sold in the Huanan Seafood Market in Wuhan, China, the most likely epicenter for the pandemic [1]. The rapid spread of the virus caught us off guard, resulted in significant morbidity and mortality across the world [2, 3]. It is estimated that approximately 80% of people who contracted this infection previous to the arrival of vaccines had a mild to moderate illness, 15% required hospitalization and 5% developed a critical illness requiring intensive care unit (ICU) [4, 5]. The symptoms that lingered and persisted after contracting COVID-19 were something that was not well known at the beginning of the pandemic [6]. Perego was the first to use the term Long-COVID on social media to denote the persistence of symptoms weeks or months after the

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initial infection [6]. In 2021 the World Health Organization (WHO) defined Long-COVID as a "Post COVID-19 condition that occurs in individuals with a history of probable or confirmed SARS CoV-2 infection, usually 3 months from the onset of COVID-19 with symptoms that last for at least 2 months and cannot be explained by an alternative diagnosis" [7–9].

Seeßle et al. observed that at 12 months, only 22.9% of the patients were completely asymptomatic. It has also been recorded that at 30 days of infection, 68% of patients had at least 1 symptoms and at 60 days, 66% of patients persisted with symptoms [10, 11]. Among the most frequent symptoms of Long-COVID are reduced exercise capacity (56.3%), fatigue (53.1%), dyspnea (37.5%), problems with concentration (39.6%), problems finding words (32.3%), and moderate to severe sleep disturbances (26.0%)[10].

Several studies conclude that the risk factors for developing Long-COVID are being women, the severity of the infection, admission to the ICU, age between 0-60 years, and having comorbidities such as high blood pressure or diabetes mellitus [12–16] It has also been identified that having a body mass index (BMI) greater than 30 predisposes patients to present severe forms of sinus after recovery from the initial infection [17]. Patients receiving supplemental oxygen more frequently present cognitive impairment or neurological deficits after being discharged from COVID-19 infection [18]. Certain ethnic groups were also more affected by certain sequelae. For example, Asians were more prone to intracranial hemorrhage problems, African-Americans were more affected by parkinsonism, while Caucasians reported more cases of dementia and insomnia [19]. Lastly, having history of SARS-CoV-2 reinfection it has been associated with greater risk of developing long-COVID[20].

One of the less frequently studied factors in the pathophysiology of COVID-19 and, therefore, of long-COVID is the role of hypobaric hypoxia to which high-altitude residents are exposed[21, 22]. In this regard, it has been speculated that living at high altitudes is associated with lower mortality due to COVID-19[23]; however, there are no studies on the long-term impacts of SARS-CoV-2 infection.

In this context, the objective of this study is to describe the epidemiology, possible risk factors, and the main symptoms associated with long-COVID, including a novel low and high-altitude analysis among Ecuadorian residents.

2. Materials and Methods

2.1. Study design and sample selection

We conducted a cross-sectional study by circulating an independent 36 item, self-reporting, online questionnaire through the internet-based survey free access platform "Shyni". We gathered anonymous responses from all over the country using a non-probability sampling method from April to July 2022. Participants were invited by social media, radio, and TV to voluntarily participate in our study.

2.2. Settings

The study was carried out in Ecuador, one of the smallest Latin American countries, located in the equatorial line and bordering the Pacific Ocean. Ecuador shares borders with Peru and Colombia, and its current population is estimated to be 17'577,116 inhabitants (24).

2.3. Population

Participants were all Ecuadorian residents who at some point during the pandemic were diagnosed with COVID-19. With a confidence level of 99% and a margin of error of 3%, our minimum estimated sample was 1,849 responses. The sample size was calculated by using the following formula:

$$x = Z(c/100)2r(100-r)$$

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$$n = N\,x/((N-1)E2 + x)$$

$$E = Sqrt[(N - n)x/n(N-1)]$$

where "N" is the population size, "r" is the minimum response rate set by default in 50%, "Z(c/100)" is the critical value for the confidence level "c", "x" is the expected population, and Sqrt is the square root. All responses included in the study came from respondents who voluntarily agreed to participate in the study and who completed all 36 questions. The study variables analyzed were age, geographical distribution at the provincial level, sex, high altitude living, comorbidities, smoking habits, number of SARS-CoV-2 infections the person has had, vaccination status and number of doses, and sequelae after recovery from COVID-19 infection. In addition, we classified the severity of the infection, based on the report of treatment received, into three categories: mild infection (those who did not receive medication or self-medicated or received medication prescribed by a doctor; moderate infection (those who had to be hospitalized for less than 3 days or 3 to 7 days) and serious infection (those who were hospitalized for more than 7 days or who were admitted to the ICU).

2.4. Survey development and measures

The data was collected using a 36-item online questionnaire to evaluate self-reported Long Covid symptoms. The participant's consent was obtained at the beginning of the questionnaire with an explanation of the objective of the study. Participants could proceed with the full questionnaire only after giving their consent by accepting (electronically marking) the Terms and Conditions and a Participation Agreement consent form. The questionnaire was developed and fielded in Spanish and later translated into English for reporting purposes. The full survey instrument is available in the Additional file 1.The questionnaire was reviewed for validity by three experts in infectious diseases and biostatistics to identify key issues that may be relevant to Long Covid symptoms and to assess its overall relevance and accuracy. In the survey, we included the EuroQol five-dimensions – 3-level (EQ5D-3L) instrument that is a versatile scale to measure quality of life (QOL) with five dimensions (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) and a visual analog scale (EQ VAS) to evaluate the perceived health state of the participant (25). After incorporating expert feedback, we pilot-tested the survey instrument online with a group of 30 eligible participants. The 30 participants who completed the pilot-testing did not participate in the final survey and the responses collected during pilot-testing were not included in the final analysis.

2.5. Data management

To ensure the highest possible accuracy in our results, we review the data case by case. This process was undertaken to identify cases where the answers did not match the questions asked. This included examples where the respondent answered that they had not presented Long Covid symptoms yet in the Long Covid symptoms section they responded with having had symptoms. Such cases were automatically eliminated from the studied sample. Additionally, some questions were also designed to identify potential pretentious answers. Where pretentious answers were identified, respondents' reports were also eliminated from the final sample. The data for this article was collected over the previous three months using a web interface questionnaire. No IP, or any other sensitive data was recorded from the respondents (Figure 1).

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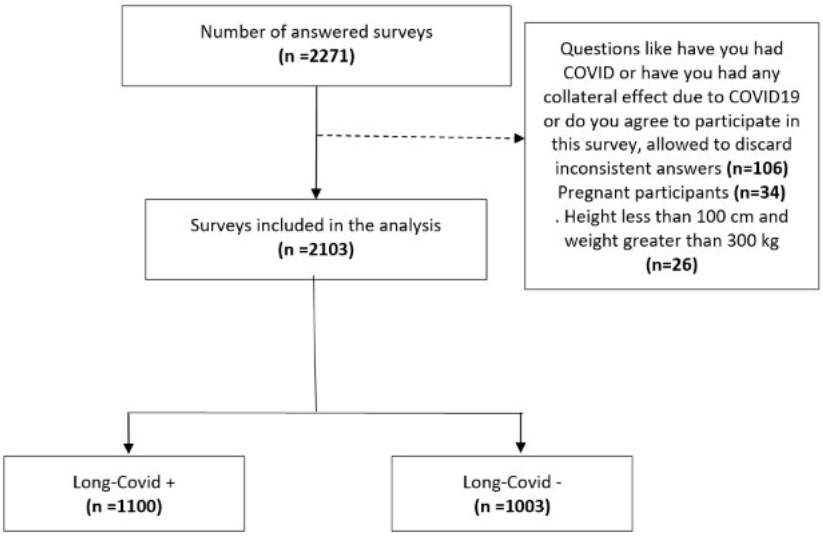

Figure 1. Breakdown of included and excluded surveys.

2.6. Statistical analysis

Descriptive and inferential analysis was conducted using the software IBM SPSS Statistics for Windows Version 24.0. The results of each item in the questionnaire were reported as men and women in percentages and absolute frequencies with no further intersex variability analysis. For quantitative variables, the Kolmogórov-Smirnov test was applied to determine data distribution, and median and interquartile ranges (IQR) were used as descriptive statistics for non-parametric variables. The Chi-Square test was used to test the association between nominal qualitative variables. A Chi-Square test for the independence of variables was chosen to search for a relationship between variables such as gender, age, comorbidities, history of COVID-19, altitude exposure, smoking habits, vaccination status and number of vaccines given. To analyze the scores of the EQ-5D-3l, the index value was calculated using Ecuador's specific scores (26). The method for calculating the p-value was based on the frequentist approach to the test. Statistical significance was accepted at $p < 0.05$. Confidence intervals at 95% from means and proportions were also computed.

2.7. Reliability and validation

Reliability was examined using a test-retest questionnaire using the final version of the survey. Since this questionnaire was created only for this project, we tested within the cohort of experts previously selected for the informal interviews.

2.8. Ethical Approval

All procedures performed in our study were in accordance with the ethical standards of the Minister of Public Health and with the Helsinki Declaration and comparable ethical standards. The current analysis did not include any personal (name, ID number, telephone number, e-mail or home address) or sensible information, complying with all local and international guidelines regarding the ethical use of this type of information. This project is part of our research program on COVID-19, a nationwide study of the epidemiology of COVID-19 in Ecuador, which received an exemption letter from the UDLA's CEISH in 2020 and received a granted letter from the Minister of Public Health.

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3. Results

3.1. General demographic information

A total of 2271 responses were collected, however, after data revalidation, 2103 responses from patients with a previous history of COVID-19 infection were included. Overall, 1100 (52.3%) responders claimed to have persistent symptoms of infection. From the positive responses, 61.0% (n = 1282) were women and 67.4% (1418) of the respondents had between 21 and 40 years of age (Table 1).

Table 1. Overall characteristics of participants with COVID-19 history.

Characteristics		Long COVID n (%)	Not long COVID n (%)	Total n	P-value
Respondents		1100 (52.3)	1003 (47.7)	2103	
Demographics					
Sex	Male	396 (48.2)	425 (51.8)	821	**0,003**
	Female	704 (54.9)	578 (45.1)	1282	
Age (years)	0 to 10	1 (33.3)	2 (66.7)	3	**< 0.001**
	10 to 20	60 (33.5)	119 (66.5)	179	
	21 to 30	382 (50.1)	381 (49.9)	763	
	31 to 40	372 (56.8)	283 (43.2)	655	
	41 to 50	191 (55.7)	152 (44.3)	343	
	51 to 60	72 (57.1)	54 (42.9)	126	
	61 to 70	15 (60.0)	10 (40.0)	25	
	71 to 80	6 (75.0)	2 (25.0)	8	
	81 to 90	1 (100.0)		1	
Residence altitude	Out of the country	5 (55.6)	4 (44.4)	9	0,368
	> 2500 m	789 (53.3)	692 (46.7)	1481	
	< 2500 m	306 (49.9)	307 (50.1)	613	
Comorbidities	No	853 (49.4)	873 (50.6)	1726	**< 0.001**
	Yes	247 (65.5)	130 (34.5)	377	
Smoke	No	993 (52.4)	901 (47.6)	1894	0,79
	Yes	107 (51.2)	102 (48.8)	209	
Alcohol	No	298 (53.0)	264 (47.0)	562	0,726
	Yes	802 (52.0)	739 (48.0)	1541	
Severity of infection	Mild	1056 (51.7)	987 (48.3)	2043	**< 0.001**
	Moderate	19 (59.4)	13 (40.6)	32	
	Severe	25 (89.3)	3 (10.7)	28	

3.2. Participants with long-term COVID19 symptoms

3.2.1. Demographic and past medical history

The participants with post-acute sequelae of COVID-19 were mostly mestizos (91.6%). In terms of sex, 64% (n = 704) were women and from the entire cohort of patients with long-term symptoms, 71.7% (n = 789) live within the highlands. From the long-COVID group, 22.5% (n = 247) had comorbidities, being the most common hypertension (25.1%) and overweight (19.0%). Only 22.5% had previous history of smoking, while 72.9% had history of consuming alcohol (Table 2).

Table 2. Demographic characteristics and history of participants with post-acute COVID-19 symptoms.

Characteristics		n	(%)
Demographics			
Sex	Male	396	36.0%
	Female	704	64.0%
	Total	1100	100.0%
Age (years)	0 to 10	1	0.1%
	10 to 20	60	5.5%
	21 to 30	382	34.7%

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	31 to 40	372	33.8%
	41 to 50	191	17.4%
	51 to 60	72	6.5%
	61 to 70	15	1.4%
	71 to 80	6	0.5%
	81 to 90	1	0.1%
	Total	1100	100.0%
Ethnicity	Mestizo	1008	91.6%
	White	59	5.4%
	Montubio	15	1.4%
	Indigenous	8	0.7%
	Afro descendants	6	0.5%
	Other	4	0.4%
	Total	1100	100.0%
Marital status	Single	587	53.4%
	Married	405	36.8%
	Divorced	62	5.6%
	Common-law	41	3.7%
	Widowed	5	0.5%
	Total	1100	100.0%
Residence altitude	Above 2500 m.	789	71.7%
	Below 2500 m.	311	28.3%
	Total	1100	100.0%
Occupation	Health care workers	238	21.6%
	Indoor workers	291	26.5%
	Outdoor workers	14	1.3%
	Workers in contact with people	324	29.5%
	Students	184	16.7%
	Unemployment and retired	49	4.5%
	Total	1100	100.0%
Weight (kg)*		66	(47 - 85)
Height (cm)*		163	(151 - 175)
BMI (kg/cm^2)*		24.8	(19.4 - 30.2)
BMI (kg/cm^2)	Underweight (< 18.5)	29	2.5%
	Normal (18.5 - 24.9)	544	49.5%
	Overweight (25.0 - 29.9)	369	33.6%
	Obesity (> 30.0)	158	14.4%
	Total	1100	100.0%
Personal history			
Comorbidities history	Yes	247	22.5%
	No	853	77.5%
	Total	1100	100.0%
Comorbidities	Arterial hypertension	66	25.1%
	Overweight	50	19.0%
	Obesity	28	10.6%
	Diabetes type 2	16	6.1%
	Asthma	27	10.3%
	HIV/AIDS	6	2.3%
	Type 1 diabetes	6	2.3%
	Hypothyroidism	43	16.3%
	Cancer	9	3.4%
	Coagulation disorders	6	2.3%
	Hyperthyroidism	6	2.3%
	Total	263	100.0%
Smoke	No	853	77.5%
	Old smoker	140	12.7%
	Yes, less 5 cigarettes a day	92	8.4%
	Yes, between 6 and 20 cigarettes per day	15	1.4%

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	Total	1100	100.0%
Alcohol	No	298	27.1%
	Once every 3 months	441	40.1%
	At least once a month	267	24.3%
	At least once a week	86	7.8%
	More than two times a week	8	0.7%
	Total	1100	100.0%
COVID-19 infection history			
Number of infections	Once	827	75.2%
	Twice	239	21.7%
	More than twice	34	3.1%
	Total	1100	100.0%
Diagnostic confirmation	PCR, antigen, or antibody tests	923	83.9%
	Physician confirmation	36	3.3%
	Infected by someone who lived with me	141	12.8%
	Total	1100	100.0%
Clinical management	None	86	7.8%
	Self-medication	160	14.5%
	Medications prescribed by a physician	810	73.6%
	Hospitalization less than 3 days	7	0.6%
	Hospitalization between 3 and 7 days	12	1.1%
	Hospitalization more than 7 days	14	1.3%
	Intensive care unit (ICU) hospitalization	11	1.0%
	Total	1100	100.0%
COVID-19 Vaccination history	No	1	0.1%
	One dose	3	0.3%
	Two doses	173	15.7%
	Two doses and one booster	781	71.0%
	Two doses and two boosters	142	12.9%
	Total	1100	100.0%
Time of infection	Infection before vaccination	561	51.0%
	Infection after vaccination	539	49.0%
	Total	1100	100.0%
Long-term COVID-19 symptoms			
Onset symptoms	Initiated with infection	449	40.8%
	3 to 4 weeks after infection	414	37.6%
	5 to 7 weeks after infection	103	9.4%
	8 to 9 weeks after infection	50	4.5%
	Later than 10 weeks post-infection	84	7.6%
	Total	1100	100.0%
Symptoms duration	Between 1 to 4 weeks	224	20.4%
	Between 4 to 8 weeks	182	16.5%
	Between 8 to 12 weeks	115	10.5%
	Between 3 to 6 months	210	19.1%
	Between 6 to 12 months	131	11.9%
	For more than 13 months	238	21.6%
	Total	1100	100.0%
Frequency of presentation	Once a month	97	8.8%
	Once every two weeks	84	7.6%
	Once a week	216	19.6%
	Over 3 days a week	297	27.0%
	Daily	331	30.1%
	Other	75	6.8%
	Total	1100	100.0%
Symptoms evolution	Has improved	389	35.4%
	Has been consistent	345	31.4%
	Intermittent (appear - disappear)	316	28.7%
	Has gotten worse	50	4.5%

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	Total	1100	100.0%
Visited a physician	Yes	492	44.7%
	No	608	55.3%
	Total	1100	100.0%
Medications prescribed by a physician	Yes	335	30.5%
	No	765	69.5%
	Total	1100	100.0%
Self-medication	Yes	367	33.4%
	No	733	66.6%
	Total	1100	100.0%

*: Median and interquartile range (IQR), BMI: body mass index, PCR: polymerase chain reaction.

Most participants used medication prescribed by a physician (73.6%) to treat COVID-19 infection and received two doses and a booster of the COVID-19 vaccine (71.0%). From those who had reported long lasting symptoms, 51.0% were infected before receiving the complete vaccination scheme. On the other hand, most symptoms occurred at the same time of infection (40.8%), and of those that experienced persistent symptoms, 30.1% said they occurred on a daily basis (Table 2).

3.2.2. Symptomatologic analysis

Of the total number of reports, we identified at least 7746 events grouped into 52 symptoms. Overall, the most self-reported symptoms were fatigue or tiredness 652 (8.4%), hair loss 391 (5.1%) and difficulty concentrating 387 (5.0%) (Figure 2).

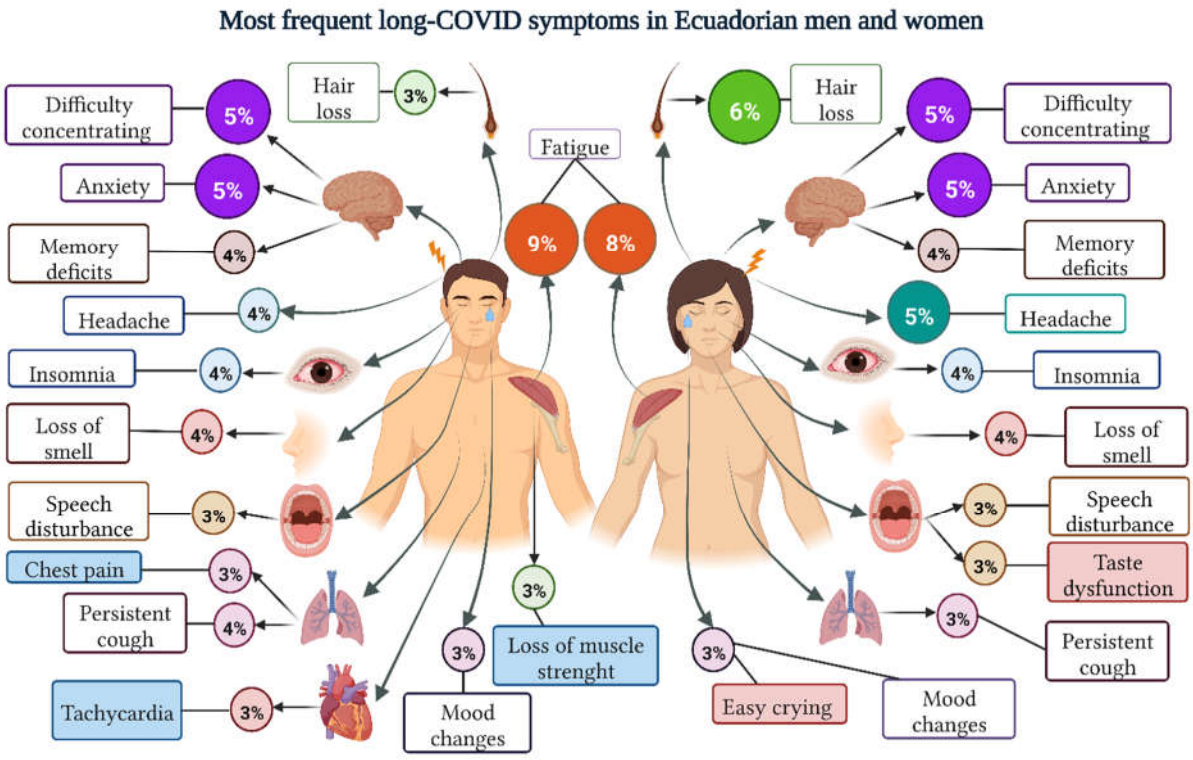

Figure 2. Prevalence of most frequent long-COVID symptoms in Ecuadorian participants according to sex.

Women reported 5405 (69.8%) of the long-term symptoms. From the total number of reports of nauseas, hair loss and altered sense of taste, women reported 85.3%, 80.8% and 71.9% respectively, being these differences statistically significant ($p < 0.05$) (Supplementary file 2).

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3.2.3. Age group analysis

The distribution of symptoms between age groups showed that most symptoms were concentrated in the 21 to 30 (33.3%) and 31 to 40 years (34.5%) age groups. The most reported symptoms among participants aged 21 to 30 years were taste dysfunction, nausea, and vomiting ($p > 0.05$), for the 31 to 40 years group they were thirst, memory impairment and confusion ($p > 0.05$) (Supplementary File 2). However, the analysis of the total number of symptoms showed differences only between the symptoms of the 21- to 30-years group and the 11 to 20 years group ($p > 0.05$) (Figure 3).

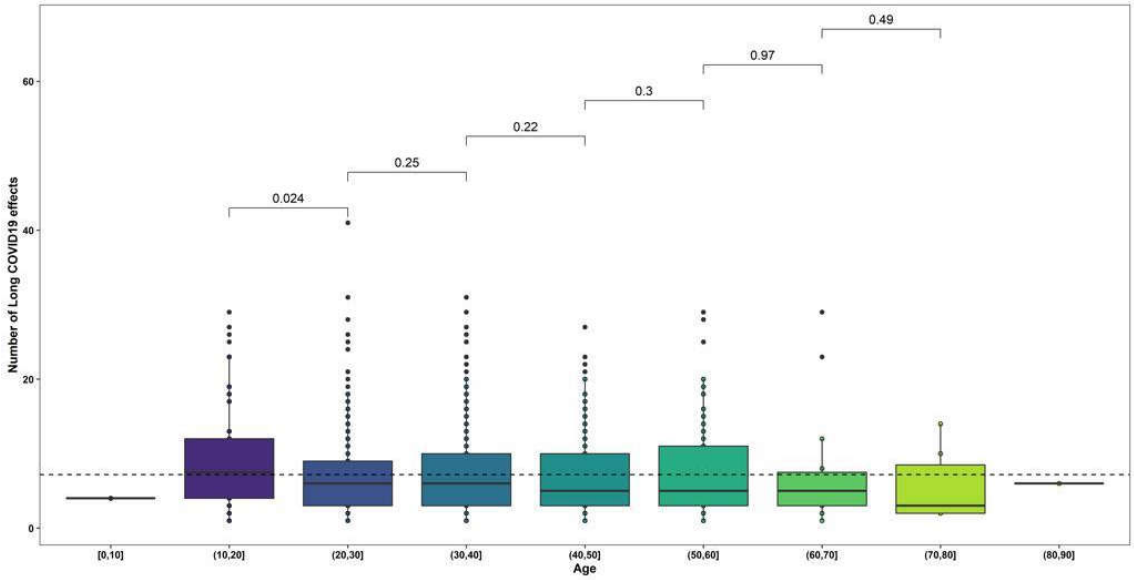

Figure 3. T-test between number of long-COVID symptoms and age groups of participants.

3.2.4. Long-Term Symptoms by vaccination status

Those patients with complete vaccine schemes and a single booster comprised the majority of Long-COVID reports 70.6% (n=5472), however, the highest proportion of symptoms was observed in the group that received only 1 dose compared to the rest of the groups ($p > 0.05$) (Table 3 and Figure 4a).

Table 3. Distribution of self-reported long-COVID symptoms according to vaccination.

Symptom		Vaccine n (%)						Time of infection n (%)		
	Total n	No Vax.	1 dose	2 doses	2 doses + 1 boosters	2 doses + 2 boosters	p Value	Before vaccine	After vaccine	p Value
Alopecia	32	--	--	7 (21.9)	23 (71.9)	2 (6.2)	0,383	16 (50.0)	16 (50.0)	0,999
Taste dysfunction	199	--	1 (0.5)	32 (16.1)	138 (69.3)	28 (14.1)	0,841	121 (60.8)	78 (39.2)	**0,002**
Alterations in glucose	16	--	--	5 (31.3)	10 (62.5)	1 (6.2)	0,202	9 (56.2)	7 (43.8)	0,864
Menstrual cycle alterations	118	--	--	16 (13.6)	81 (68.6)	21 (17.8)	0,231	56 (47.5)	62 (52.5)	0,473
Hallucinations	20	1 (5.0)	--	6 (30.0)	13 (65.0)	--	**<0.001**	13 (65.0)	7 (35.0)	0,299
Anxiety	379	1 (0.3)	1 (0.3)	68 (17.9)	271 (71.5)	38 (10.0)	0,114	205 (54.1)	174 (45.9)	0,154
Brittle hair	111	--	--	16 (14.4)	81 (73.0)	14 (12.6)	0,901	65 (58.6)	46 (41.4)	0,114
Mood changes	234	--	--	40 (17.1)	173 (73.9)	21 (9.0)	0,119	123 (52.6)	111 (47.4)	0,641
Tachycardia	184	1 (0.5)	1 (0.5)	32 (17.4)	131 (71.3)	19 (10.3)	0,13	99 (53.8)	85 (46.2)	0,451
Blood pressure changes	74	--	1 (1.3)	13 (17.6)	51 (68.9)	9 (12.2)	0,303	42 (56.8)	32 (43.2)	0,365
Confusion	61	1 (1.6)	--	18 (29.5)	39 (64.0)	3 (4.9)	**<0.001**	39 (63.9)	22 (36.1)	0,051
Diarrhea	56	--	--	10 (17.9)	36 (64.2)	10 (17.9)	0,436	32 (57.1)	24 (42.9)	0,419
Difficulty concentrating	387	--	2 (0.5)	59 (15.2)	270 (69.8)	56 (14.5)	0,449	214 (55.3)	173 (44.7)	**0,042**
Speech disturbance	241	--	1 (0.4)	45 (18.7)	159 (66.0)	36 (14.9)	0,26	126 (52.3)	115 (47.7)	0,705
Decreased visual acuity	147	--	1 (0.7)	29 (19.7)	100 (68.0)	17 (11.6)	0,361	92 (62.6)	55 (37.4)	**0,003**
Loss of muscle strength	170	--	--	32 (18.8)	128 (75.3)	10 (5.9)	**0,009**	91 (53.5)	79 (46.5)	0,526

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Decreased libido/sexual desire	115	--	--	18 (15.7)	81 (70.4)	16 (13.9)	0,949	60 (52.2)	55 (47.8)	0,866
Abdominal pain	70	--	--	11 (15.7)	47 (67.2)	12 (17.1)	0,551	32 (45.7)	38 (54.3)	0,429
Headache	354	1 (0.3)	1 (0.3)	56 (15.8)	246 (69.5)	50 (14.1)	0,578	184 (52.0)	170 (48.0)	0,702
Chest pain	187	--	1 (0.5)	31 (16.6)	136 (72.7)	19 (10.2)	0,555	92 (49.2)	95 (50.8)	0,644
Burning sensation in any part of the body	75	--	--	15 (20.0)	57 (76.0)	3 (4.0)	**0,046**	40 (53.3)	35 (46.7)	0,764
Unusual muscle aches	109	--	1 (0.9)	18 (16.5)	77 (70.7)	13 (11.9)	0,576	56 (51.4)	53 (48.6)	0,999
Usual muscle aches	164	--	1 (0.6)	33 (20.1)	112 (68.3)	18 (11.0)	0,269	88 (53.7)	76 (46.3)	0,513
Shaking chills	45	--	1 (2.2)	8 (17.8)	33 (73.3)	3 (6.7)	**0,043**	22 (48.9)	23 (51.1)	0,891
Sneezing	92	--	1 (1.0)	11 (12.0)	71 (77.2)	9 (9.8)	0,199	41 (44.6)	51 (55.4)	0,237
Fatigue or tiredness	652	1 (0.2)	2 (0.3)	101 (15.5)	460 (70.5)	88 (13.5)	0,863	331 (50.8)	321 (49.2)	0,9
Tingling in extremities	137	--	--	25 (18.3)	101 (73.7)	11 (8.0)	0,159	76 (55.5)	61 (44.5)	0,303
Insomnia	342	--	--	54 (15.8)	252 (73.7)	36 (10.5)	0,262	175 (51.2)	167 (48.8)	0,991
Heat intolerance	20	--	--	6 (30.0)	12 (60.0)	2 (10.0)	0,211	10 (50.0)	10 (50.0)	0,999
Cold intolerance	92	--	--	16 (17.4)	65 (70.6)	11 (12.0)	0,883	54 (58.7)	38 (41.3)	0,151
Nausea	68	--	1 (1.5)	13 (19.1)	47 (69.1)	7 (10.3)	0,19	31 (45.6)	37 (54.4)	0,425
Neuritis	96	--	--	20 (20.8)	65 (67.7)	11 (11.5)	0,355	48 (50.0)	48 (50.0)	0,921
Palpitations	182	1 (0.6)	1 (0.5)	30 (16.5)	125 (68.7)	25 (13.7)	0,197	96 (52.8)	86 (47.2)	0,663
Facial paralysis	7	--	--	1 (14.3)	5 (71.4)	1 (14.3)	0,99	5 (71.4)	2 (28.6)	0,48
Loss of appetite	55	--	1 (1.8)	9 (16.4)	39 (70.9)	6 (10.9)	0,153	23 (41.8)	32 (58.2)	0,207
Hearing loss	49	--	--	7 (14.3)	36 (73.5)	6 (12.2)	0,937	33 (67.3)	16 (32.7)	**0,028**
Hair loss	391	--	2 (0.5)	62 (15.9)	274 (70.0)	53 (13.6)	0,672	227 (58.1)	164 (41.9)	**<0.001**
Loss of taste	172	--	1 (0.6)	27 (15.7)	125 (72.7)	19 (11.0)	0,719	114 (66.3)	58 (33.7)	**<0.001**
Memory deficits	287	--	2 (0.7)	54 (18.8)	196 (68.3)	35 (12.2)	0,14	155 (54.0)	132 (46.0)	0,264
Muscle loss	97	--	1 (1.0)	12 (12.4)	69 (71.1)	15 (15.5)	0,315	59 (60.8)	38 (39.2)	0,054
Loss of smell	263	--	2 (0.8)	37 (14.1)	190 (72.2)	34 (12.9)	0,296	170 (64.6)	93 (35.4)	**<0.001**
Body hair loss	14	--	--	2 (14.3)	12 (85.7)	--	0,978	7 (50.0)	7 (50.0)	0,999
Pruritus (itching)	114	--	--	22 (19.3)	76 (66.7)	16 (14.0)	0,475	66 (57.9)	48 (42.1)	0,145
Gastroesophageal reflux	87	--	--	16 (18.4)	62 (71.3)	9 (10.3)	0,636	51 (58.6)	36 (41.4)	0,17
Skin dryness	139	--	--	28 (20.1)	98 (70.5)	13 (9.4)	0,171	71 (51.1)	68 (48.9)	0,999
Thirst	77	--	1 (1.3)	11 (14.3)	61 (79.2)	4 (5.2)	**0,048**	30 (39.0)	47 (61.0)	**0,038**
Easy crying	202	--	--	40 (19.8)	138 (68.3)	24 (11.9)	0,217	114 (56.4)	88 (43.6)	0,102
Excessive sweating	90	--	1 (1.1)	16 (17.8)	59 (65.5)	14 (15.6)	0,292	51 (56.7)	39 (43.3)	0,311
Tremor of the extremities	90	--	--	20 (22.2)	59 (65.6)	11 (12.2)	0,216	48 (53.3)	42 (46.7)	0,724
Persistent cough	245	--	1 (0.4)	28 (11.4)	185 (75.5)	31 (12.7)	0,184	93 (38.0)	152 (62.0)	**<0.001**
Brittle nails	113	--	--	20 (17.7)	80 (70.8)	13 (11.5)	0,778	58 (51.3)	55 (48.7)	0,999
Vomit	25	--	1 (4.0)	4 (16.0)	17 (68.0)	3 (12.0)	**0,004**	10 (40.0)	15 (60.0)	0,362
Total	**7746**	**7**	**31**	**1310**	**5472**	**926**		**4164**	**3582**	

On the other hand, the influence of the time of infection in relation to the time of receiving the vaccine showed that participants who were infected before receiving the vaccine had more symptoms 53.7% (n=4164), such as hair loss, loss of smell, loss of taste, difficulty concentrating and alterations in taste ($p > 0.05$), while among participants who were infected after being vaccinated, persistent cough was higher ($p > 0.05$) (Table 3).

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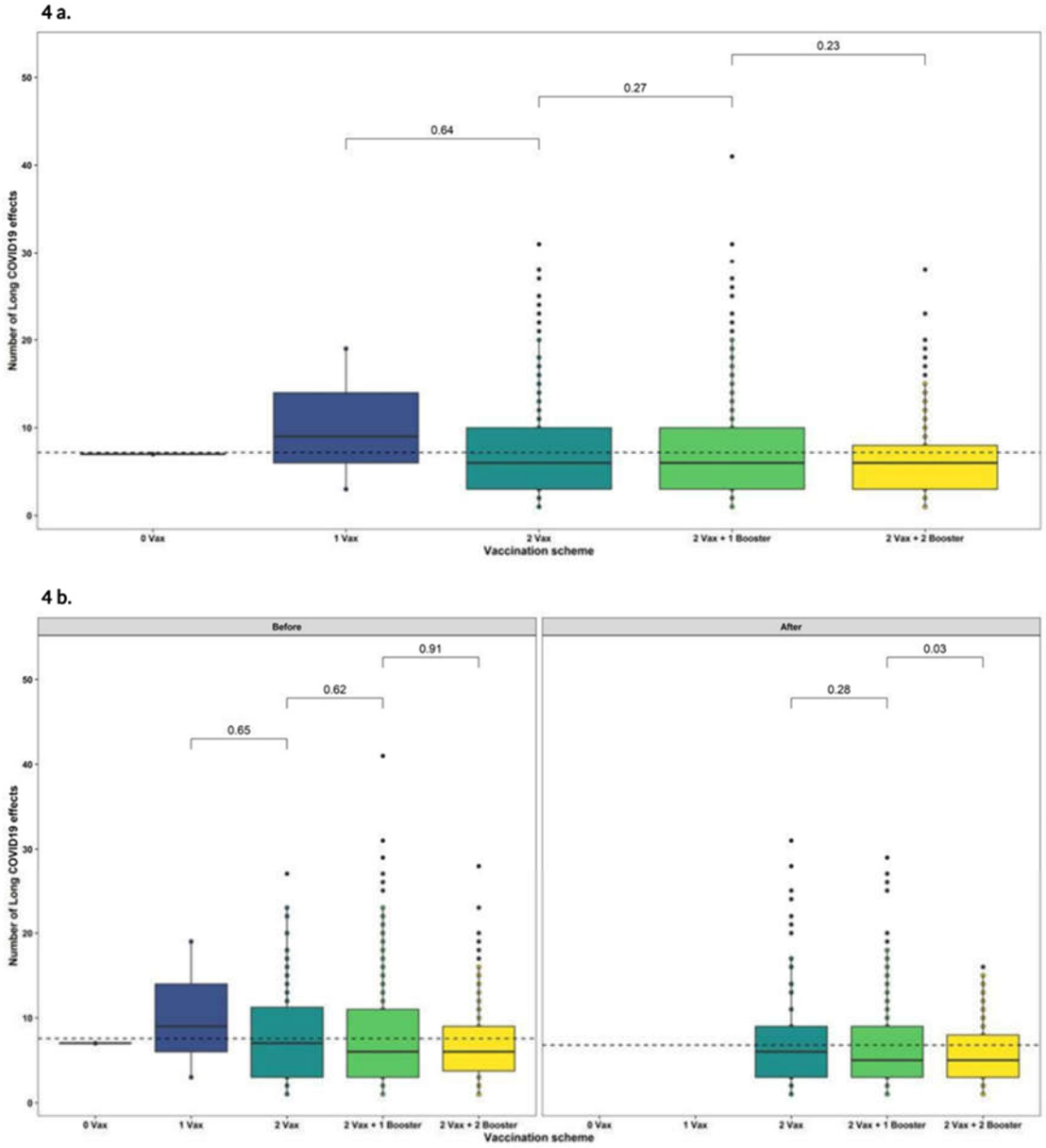

Figure 4. Effect of vaccination on long-COVID symptoms in Ecuadorian participants. 4a. T-test between number of long-COVID symptoms and vaccine received doses. 4b. T-test between number of symptoms and vaccine doses received according to the time of infection.

Regarding the total number of symptoms, the proportion of symptoms was higher in participants who were infected after having had 2 doses of vaccine and 1 booster compared to those who had 2 doses and 2 boosters ($p > 0.05$) (Figure 4b).

3.3. High Altitude of residence

Overall, the population residing at high altitude reported a slightly higher proportion 14.3% (5503 symptoms in 789 participants) of long-COVID symptoms when compared to the low-landers 13.7% (2228 symptoms in 306 participants) ($p < 0.001$) (Figure 5a). While, in low altitudes residents a higher proportion of long-COVID symptoms was found in men ($p = 0.003$), opposite tendency to that found at high altitudes (Figure 5b).

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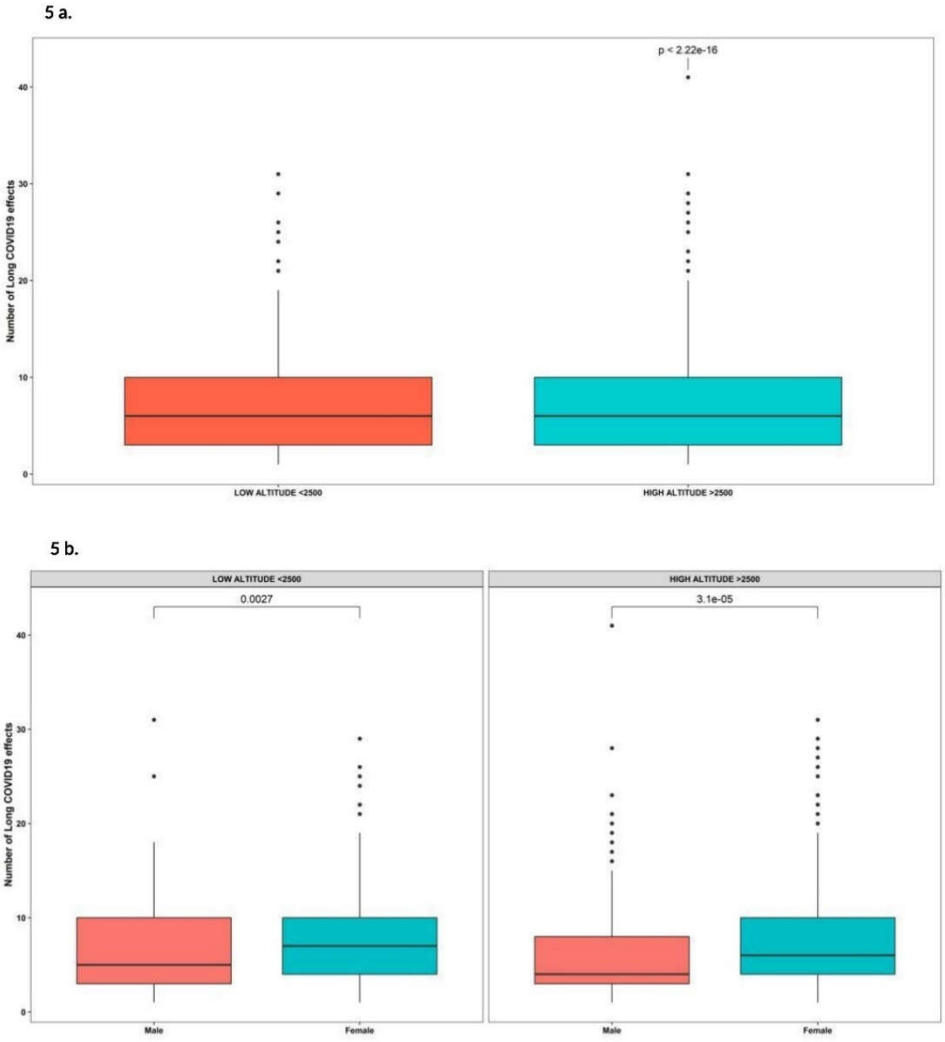

Figure 5. Differences in long-COVID symptoms according to altitude. 5a. T-test between the number of long-COVID symptoms and altitude. 5b. T-test between the number of long-COVID symptoms and altitude according to sex.

On various long-COVID symptoms such as mood changes, tachycardia, decreased libido/sexual desire, and insomnia, a higher frequency was found in high altitude participants ($p < 0.05$) (Table 4). We also found a significantly earlier onset of symptoms ($p = 0.004$) in high altitude participants. Also, when comparing the proportion of patients having sequalae that last longer than a year, high altitude dwellers have a higher probability ($p = 0.007$) to report symptoms after12 months (Table 4).

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Table 4. Long-COVID symptoms and their characteristics according to the altitude of the participants' residence.

		Altitude n (%)				
		Out of the country	< 2500 m	> 2500 m	p Value	Total n
Symptoms*	Taste dysfunction	--	46 (23.1)	153 (76.9)	0.111	199
	Menstrual cycle alterations	1 (0.9)	26 (22.0)	91 (77.1)	0.276	118
	Anxiety	1 (0.3)	114 (30.0)	264 (69.7)	0.392	379
	Brittle hair	--	33 (29.7)	78 (70.3)	0.741	111
	Mood changes	--	79 (33.8)	155 (66.2)	**0.031**	234
	Tachycardia	--	67 (36.4)	117 (63.6)	**0.006**	184
	Difficulty concentrating	1 (0.3)	101 (26.1)	285 (73.6)	0.485	387
	Speech disturbance	--	59 (24.5)	182 (75.5)	0.202	241
	Decreased visual acuity	1 (0.7)	44 (29.9)	102 (69.4)	0.743	147
	Loss of muscle strength	1 (0.6)	54 (31.8)	115 (67.6)	0.433	170
	Decreased libido/sexual desire	1 (0.9)	43 (37.4)	71 (61.7)	**0.038**	115
	Headache	--	98 (27.7)	256 (72.3)	0.951	354
	Chest pain	--	59 (31.6)	128 (68.4)	0.263	187
	Unusual muscle aches	--	27 (24.8)	82 (75.2)	0.505	109
	Usual muscle aches	--	46 (28.0)	118 (72.0)	0.999	164
	Fatigue or tiredness	3 (0.5)	188 (28.8)	461 (70.7)	0.66	652
	Tingling in extremities	--	43 (31.4)	94 (68.6)	0.39	137
	Insomnia	2 (0.6)	114 (33.3)	226 (66.1)	**0.02**	342
	Palpitations	--	66 (36.3)	116 (63.7)	**0.008**	182
	Hair loss	2 (0.5)	113 (28.9)	276 (70.6)	0.815	391
	Loss of taste	--	47 (27.3)	125 (72.7)	0.916	172
	Memory deficits	1 (0.4)	73 (25.4)	213 (74.2)	0.542	287
	Loss of smell	--	67 (25.5)	196 (74.5)	0.344	263
	Pruritus (itching)	--	35 (30.7)	79 (69.3)	0.56	114
	Skin dryness	--	32 (23.0)	107 (77.0)	0.199	139
	Easy crying	--	59 (29.2)	143 (70.8)	0.721	202
	Persistent cough	1 (0.4)	75 (30.6)	169 (69.0)	0.54	245
	Brittle nails	--	30 (26.6)	83 (73.4)	0.811	113
	Total					**6338**
Symptom characteristics						
Onset time	Initiated with infection	4 (0.9)	104 (23.2)	341 (76.0)	**0.004**	
	3 to 5 weeks after infection	1 (0.2)	126 (30.4)	287 (69.3)	0.243	
	5 to 7 weeks after infection	.	28 (27.2)	75 (72.8)	0.948	
	7 to 9 weeks after infection	.	15 (30.0)	35 (70.0)	0.865	
	After 9 weeks of infection	.	33 (39.3)	51 (60.7)	**0.022**	
Symptoms duration	Between 1 to 4 weeks	.	53 (23.7)	171 (76.3)	0.129	
	Between 4 to 8 weeks	.	47 (25.8)	135 (74.2)	0.543	
	Between 8 to 12 weeks	3 (2.6)	28 (24.4)	84 (73.0)	**0.001**	
	Between 3 to 6 months	.	60 (28.6)	150 (71.4)	0.889	
	Between 6 to 12 months	.	34 (26.0)	97 (74.1)	0.662	
	More than 12 months	2 (0.8)	84 (35.3)	152 (63.9)	**0.007**	
Frequency of presentation	Once a month	.	23 (23.7)	74 (76.3)	0.393	
	Once every two weeks	.	20 (23.8)	64 (76.2)	0.452	
	Once a week	.	75 (34.7)	141 (65.3)	**0.016**	
	Over 3 days a week	2 (0.7)	82 (27.6)	213 (71.7)	0.804	
	Daily	3 (0.9)	94 (28.4)	234 (70.7)	0.324	
	Total	**15**	**918**	**2367**		

M: meters above sea level; *: The complete list of symptoms distributed 1according to altitude is available in the supplementary file 4.

3.4. Symptoms onset, length, and duration

The duration of long-COVID symptoms shows a similar trend between men and women. (Supplementary file 3b). The most self-reported long-COVID symptoms and

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those that last the longest are fatigue, loss of taste (Ageusia), loss of smell (anosmia), and persistent cough (Supplementary file 5). In terms of duration, 24.5% (n = 1899) of self-reported symptoms have been experienced at least for 12 months daily in 25.9% of patients (n=2003), and more than three days per week in 29.5% of respondents (n=2284) (Supplementary file 5 and 6).

3.5. Risk of post-acute COVID-19 symptoms

Based on the data from all respondents (n = 2103), the risk of developing long-COVID symptoms in Ecuadorians was higher among women OR = 1.31 (95%CI: 1.097 - 1.558) compared to men, as well as in patients who reported having comorbidities OR = 1.95 (95%CI: 1.541 - 2.453) compared to those who did not. A significant higher risk of having post-acute symptoms was also observed among those with severe infection history OR = 7.79 (95%CI: 2.344 - 25.878) when compared to those who had a milder infection (Table 5).

Table 5. Risk analysis for long-COVID symptoms iin Ecuadorian participants.

Characteristics		Long COVID	Not long COVID	OR (95% CI)
		(n)	(n)	
Sex	Men *(ref.)*	396	425	**1.31 (1.10 - 1.56)**
	Women	704	578	
Altitude	Low *(ref.)*	306	307	1.14 (0.95 - 1.38)
	High	789	692	
Comorbidities	No *(ref.)*	853	873	**1.95 (1.541 - 2.453)**
	Yes	247	130	
Smoke	No *(ref.)*	993	901	0.95 (0.72 - 1.27)
	Yes	107	102	
Alcohol	No *(ref.)*	298	264	0.96 (0.79 - 1.17)
	Yes	802	739	
Severity of infection	Mild *(ref.)*	1056	987	
	Moderate	19	13	1.37 (0.67 - 2.78)
	Severe	25	3	**7.79 (2.34 - 25.88)**

OR: Odds Ratio.

3.6. Risk by number of COVID-19 infections

Among participants with long-COVID symptoms, the effect of the number of previous infections as a risk factor for prolonged duration of long-COVID symptoms was evident; participants who reported a history of more than 1 COVID-19 infection had a higher risk (RR = 1.296; 95%CI:1.076 - 1.560) of having sequelae lasting longer than 6 months (Supplementary file 7). Similarly, the group of participants who claimed to have a history of more than 1 infection had an increased risk (RR = 1.329; 95%CI:1.042 - 1.696) of having sequelae with duration greater than 12 months (Supplementary file 8).

3.7. Health-related quality of life of participants with post-acute COVID

Health-related quality of life of participants with post-acute COVID was measured using the EQ-5D-3L. 8.0% of participants reported problems with self-care, 13.0% problems with mobility, 31.2% problems with usual activities, 81.4% with pain/discomfort and 98.9% reported experiencing anxiety and depression. The average index value for health status was .84 (SD = .08) and it was negatively correlated with number of experienced symptoms (r = - .14). The average VAS score was 75.27 (SD = 21.34) and it was also negatively correlated with the number of symptoms (r = - .21).

4. Discussion

To the best of our knowledge, this is the first study in South America to examine the post-acute symptoms of SARS-CoV-2 virus infection in a population with and without a history of hospitalization due to infection. This analysis revealed that women, young

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adults, overweight patients, patients without comorbidities, participants who were infected prior to vaccination, and participants who have received incomplete vaccine schemes developed more symptoms of long COVID.

The participants of this research mostly claimed to have a confirmed diagnosis through laboratory tests or medical examination (83.9% and 3.3%), however, the answers from those who claimed to have been infected by continuity (contagion by coexistence with an infected person with a confirmed diagnosis) were included as valid. Despite representing only, a small portion of Ecuador's population (n = 2103), this study showed that just over half (52.3%) of participants with a history of COVID-19 infection developed at least 1 long-term sequelae of the infection. This corroborates the results found by Walsh-Messinger. et al. where a 51% prevalence of "post COVID syndrome" in self-reported university students who experienced mild to moderate infection (not hospitalized) was reported [24], as well as a self-reported prevalence of 60% among Spanish participants with a history of hospitalization [25]. On the other hand, a self-reported investigation of 310 individuals from several countries (Norway, United Kingdom, United States and Australia) showed a lower prevalence (28.7%) of long-COVID sequalae when compared to our results [26], nevertheless, in a systematic review a prevalence of 43% was estimated at a global level [27].

We were able to show that the participants managed to describe the existence of 52 different symptoms in a total of 7746 occasions. These consequences affected several organs and systems, causing health problems not only in the physical aspect but also in the neurocognitive and emotional aspect. The most frequently reported sequelae were fatigue or tiredness (8.4%), followed by hair loss (5.0%) and difficulty concentrating (5.0%). These findings are similar to those found in meta-analyses and large population studies that place fatigue and hair loss among the most prevalent post-COVID symptoms [27–29]. Similarly, in studies that based their analyses on self-reported information on neurological sequelae, Bungenberg et al. found that the most frequent symptoms were difficulties in attention and concentration, and fatigue among hospitalized and non-hospitalized participants [30], while the results in patients with history of hospitalization showed that the most frequent symptoms were memory deficit and attention deficit [31].

Regarding sex, it was evidenced that women presented more post-acute symptoms (feeling of anxiety, brittle hair, difficulty concentrating, headache, insomnia, nausea, neuritis, hair loss, memory defects, muscle loss, dry skin, easy crying, and brittle nails) when compared to men, findings similar to those presented by Sudre et al. and Whitaker et al. in self-report studies in the population of the United Kingdom [32, 33], Mexico [34] and Spain [25]. While these differences may be because women are more likely to participate in this type of investigations and are more aware of their health, only one study has shown that men are more likely to develop long-covid than women [26, 35].

With respect to the age of the participants, we observed that the post-acute symptoms of COVID-19 are more likely reported by young adults between 20 and 40 years old. A total of 21 symptoms including taste dysfunction, confusion, tingling in the extremities, nausea, memory defects, among others showed to be significantly more frequent in this younger group compared to the groups of other ages. These results corroborate that of a similar study in the UK population with no history of hospitalization and in which the risk of reporting symptoms of long-COVID decreases with age [29].

The effect of comorbidities on the self-reported results reveals unexpected behavior within our sample of respondents. In particular, a higher frequency of post-acute symptoms was observed in participants who claimed to have no history of comorbidities than those with comorbidities. However, in the risk analysis comparing the group of patients without symptoms of long-COVID, it was found that having comorbidities is a risk factor for the development of post-acute symptoms (OR = 1.95; 1.541 - 2.453). These discrepancies are possibly caused by most of the responders not being diagnosed with comorbidities. The effects of concomitant diseases have been seen in the studies of Subramanian et al., and Fernández-de-las-Peñas et al., in populations of United Kingdom and Spain, respectively [29, 36]. Similarly, in relation to the body mass index of the participants, those

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who reported having a normal BMI (18.5 - 24.9) had a higher number of post-acute symptoms compared to the rest of the groups ($p > 0.05$), however, in a separate analysis it was evidenced that peripheral symptoms such as decreased strength, burning sensation in the body, tingling of limbs and reflux were significantly more frequent in participants in the overweight group compared to the others. Research in participants with and without a history of hospitalization in England, as well as in non-hospitalized groups in United Kingdom, has found overweight and obesity as risk factors for the development of long-COVID symptoms (HRa = 1.07; 1.04–1.10) (HRa = 1.10; 1.07–1.14), respectively [29, 33].

In relation to ethnicity, the mestizo (mixed) ethnic group showed significantly more post-acute symptoms than the rest of the ethnic groups. However, again, we believe that this result may reflect the fact that the largest number of responders were from this group, consistent with the fact that the mestizo ethnic group is the most prevalent in Ecuador (71.9%) [37]. In any case, we consider this interesting finding to be supported by the results presented by Subramanian et al. based on data from a large population study in the United Kingdom, in which being of mestizo ethnicity was associated with an increase in risk (HRa = 1.14; 1.07–1.22) of developing symptoms of long-COVID taking as a reference group the white ethnic group [29], however, most of the reports published so far base their results on the analysis of populations with groups that have almost no mestizo individuals, unlike the Ecuadorian population that was investigated in this report.

Regarding habits, the risk analysis stated that alcohol consumption and smoking do not represent a risk condition for the development of post-acute symptoms of infection by the SARS-CoV-2 virus. However, several reports from online surveys have shown that the habit or history of smoking increases the risk of post-acute symptoms especially tachycardia and / or hypertension in the case of population of France, as well as in inhabitants of the United Kingdom (HRa = 1.12; 1.08–1.15), (HRa = 1. 08; 1.05–1.11) [29, 33, 38].

The effect of the severity of the infection (antecedent) characterized by the treatment that the participants claimed to receive showed that in contrast to responders who did not develop sequelae, having presented severe infection pictures (hospitalization for more than 7 days and / or hospitalization in the intensive care unit) was a great risk condition (OR = 7.79; 2.34 - 25.88) for the development of post-acute sequelae of COVID-19 when compared with mild infection (outpatient treatment and non-treatment).Similar effects have been evidenced in various studies characterized by the use of mechanical ventilation, and having been hospitalized [27, 31, 33, 34].

The evaluation of the effect of vaccines on post-acute symptoms showed that respondents with two of the recommended boosters are less likely to develop long term symptoms when compared to those with incomplete vaccination status. As users of two doses plus two boosters showed a lower number of post-acute symptoms, we trust in the protective effects that vaccines have shown for the development of post-acute sequelae of COVID-19 in other studies [39, 40]. In the same context, when assessing the role of the time individuals acquire infection in relation to the timing of vaccination, we found that the frequency of long-term symptom presentation was significantly higher in participants who acquired the infection before being vaccinated. The symptoms in non-vaccinated patients were frequently difficulty concentrating, decreased visual acuity, hair loss, loss of taste and loss of smell. Alternatively, for participants who acquired the infection after being vaccinated with two doses plus two boosters of the vaccine, there was found to be a significant decrease in the number of post-acute symptoms. A partially similar effect was described by Ayoubkhani et al. in the United Kingdom, who demonstrated a decrease in long-term symptoms in participants who were infected before vaccination [40].

We observed that the duration of symptoms reported was variable, but in many cases greater than 12 months (24.5%). The analysis of the time of onset and the frequency of presentation of symptoms incorporated extra aspects relative to those incorporated in the definition of a "long COVID case" of daily presentation proposed by the WHO [7], thus, we found that the highest number of post-acute symptoms had onset with the virus infection (42.1%), although not large in number, out study collected information regarding symptoms that began up to 9 weeks after suffering the infection. The present study also

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discovered that the majority of participants said that these persistent symptoms occur on more than 3 days per week (29.5%) and often daily (25.9%). This latter trait was also observed in participants from the United Kingdom and the United States who reported that the greatest number of symptoms occurs daily 72.2% and on more than three occasions per week 18.8% [41].

The products of the behavior analysis of the symptoms separately reveals that the symptom onset time can differ by symptom. Specifically, the onset of symptoms together with the infection exposed a significantly higher frequency in the diffusion of taste, diarrhea, fatigue, loss of appetite, loss of taste, loss of smell and persistent cough. These results are unlike the findings of Ziauddeen et al., where data from 2550 non-hospitalized participants from the United Kingdom and the United States found that the most frequent long-lasting initial symptoms were exhaustion, chest pressure difficulty and headache [41]. Regarding the evolution of the symptoms, our participants presented widely distributed evolution traits. The least reported pattern of symptom evolution was the worsening of the symptoms from their presentation (5.6%), while the intermittent pattern was the most common (32.1%). In such cases the presentation was characterized by symptoms significantly greater than the rest of the patterns such as tachycardia, decreased visual acuity, loss of muscle strength, decreased sex drive, chest pain, dry skin, easy crying; all behavior similar to that described by Ziauddeen et al. where the majority of participants (57.7%) described fluctuating symptoms [41]. In relation to the duration of symptoms, the most frequently reported symptoms of a prolonged duration were chest pain and persistent cough, which lasted mostly between 4 and 8 weeks. On the other hand, there are many symptoms of a psychic origin (confusion, difficulty concentrating, speech difficulty, memory deficit), of neuronal origin (loss and dysfunction of taste, loss of smell), and considered peripheral (intolerance to cold, tingling of the limbs, hair loss) that have been reported to persist with a duration greater than 12 months from the infection. This differs from the self-report study of Sudre et al. that showed that loss of smell, shortness of breath and fatigue were the symptoms of greater duration, however, that the duration of these was found to be only between 40 and 70 days approximately [32].

Symptom characteristics, such as time of onset, duration, and frequency of presentation, were little altered by many variables studied (sex, comorbidities, vaccination, ethnicity, age). However, a unique result from the present study shows that the altitude analysis reveals that the post-acute symptoms of the participants residing in areas located above 2500 m tend to occur with lower frequencies (once a week). Nevertheless, while the frequency of the symptom presentation is lower, the duration of symptoms in this group is apparently longer compared to that observed in residents below 2500. Although there are distinct results in patients by altitude, the risk analysis did not expose altitude as a risk condition for the development of post-acute symptoms of COVID-19. Despite certain differences described during the acute course of infection in high-altitude and low-altitude populations such as incidence and mortality [21, 42], this is the first time that this variable is included in the study of post-acute symptoms of COVID-19.

More research is needed to estimate the prevalence of post-acute symptoms associated with the history of infection by the SARS-CoV-2 virus among inhabitants of South America. In current studies, the role of ethnic differences during the sequelae of the disease could be underestimated because of the scarcity of information from populations with a large degree of miscegenation. Future studies could also examine the wide range of sociodemographic factors that have been associated with the development of these symptoms, of which the South American region has marked differences in its inhabitants.

Our study has several limitations which are inherent to its self-reported cross-sectional design. Since the questionnaire was distributed through social networks, information pertaining to the population that does not have the resources to access an online questionnaire was left out of the study. Likewise, most older adults handle electronic devices and the Internet with difficulty. This may cause a selection bias. However, we believe that this bias was minimized by using a substantial sample size taken from the data of the Ecuadorian population that was infected by the SARS-CoV-2 virus. Another

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limitation of this type of study is the absence of accurate and verified past medical history, as in the case of severity of infection. Nevertheless, we attempted to assess these variables by using more objective questions such as general characteristics of hospitalization that are more likely to be accurately captured by participants. On the other hand, unlike other studies that similarly sought to evaluate post-acute symptoms of COVID-19 from diagnoses confirmed by laboratory studies, in this research we accepted cases of patients who claimed to have contracted the disease by continuity. This is important in a country like Ecuador where the social reality allows for a limited capacity of access to confirmatory laboratory tests for the population. Social desirability bias is another potential limitation that could have affected the responses due to the self-report nature of the questionnaire.

5. Conclusions

This is the first study on the long-term sequelae of COVID-19 in Ecuador and, to our knowledge, the first of its kind in South America. The results of this study on self-reported symptoms of long-COVID show that in Ecuador, at least half of those previously infected with SARS-CoV-2 have at least one persistent symptom after overcoming the disease. From the self-reported list of persistent symptoms, fatigue, anosmia, ageusia, hair loss and difficulty concentrating are among the most common ongoing conditions, lasting in many cases more than a year after COVID-19. We found that young adults, especially those with past medical history of severer COVID-19 and those with more than one infection are more likely to report having more sequalae that persist longer than those with no previous infection. High altitude dwellers have a slightly greater probability to report long-COVID symptoms, that in every case are reported earlier and last longer than the low land counterpart.

Supplementary Materials: Additional file 1

Author Contributions: EOP and JSIC were fully responsible for the conceptualization and for the content presented in this study. JSIC, JVG, SC, ATDT, KDM, CP, and EOP were responsible for recruiting the questionnaire information. RFN, JSIC and EOP were responsible for the statistical analysis and data representation. JSIC, JVG and EOP contributed with the drafting of the first version of the manuscript. GV and CP contributed within the discussion section and critically reviewed the entire manuscript. JSIC and EOP wrote the final version of the present study. All authors reviewed and accepted the final version of the manuscript..

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Data Availability Statement: The dataset with the total responses can be obtained from the authors upon reasonable request. The questionnaire summary and its results are included in this article.

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Conflicts of Interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.".

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