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## Covid-19: Signs and symptoms related to the feeding behavior

Alessandra Salles Machado<sup>a,\*</sup>, Paula Midori Castelo<sup>b</sup>, Fernando Capela e Silva<sup>c,d</sup>, Elsa Lamy<sup>c,\*\*</sup>

<sup>a</sup> Department of Speech Therapy, University Vila Velha (UVV), Brazil

<sup>b</sup> Department of Pharmaceutical Sciences, Institute of Environmental, Chemical and Pharmaceutical Sciences, University Federal de São Paulo (UNIFESP), Brazil

<sup>c</sup> MED - Mediterranean Institute for Agriculture, Environment and Development, IIFA - Instituto de Investigação e Formação Avançada, University of Évora, Portugal

<sup>d</sup> Department of Medical and Health Sciences, School of Health and Human Development, University of Évora, Évora, Portugal

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### ABSTRACT

COVID-19 reached pandemic level in March 2020 and the number of confirmed cases continued to increase worldwide. The clinical course of the disease has not yet been fully characterized, and some specific symptoms related to smell, taste, and feeding behavior require further examination. The present study aimed to assess the presence of symptoms related to the feeding behavior occurred during and/or after COVID-19 in adults residing in Portugal and to link them to disease severity using a multivariate approach. Data were collected from May to September 2020, through a questionnaire answered online containing questions about general and specific symptoms before, during and after COVID-19. 362 participants were included: 201 were symptomatic, being 15 hospitalized and 186 non-hospitalized. Cluster analysis grouped the symptomatic non-hospitalized participants as mild and severe cases. For these patients, the most frequent symptoms related to the feeding process were smell disorders in 40% and 62%, taste disorders in 37% and 60%, and dry mouth, in 23% and 48% of the mild and severe cases, respectively. Dry mouth was significantly associated with difficulty to swallow, pain during swallow, choking when eating or drinking, and preference for mushy/pasty foods ( $p < 0.01$ ; Chi-squared test). Among the severe cases, the incidence of coughing during the meal (31%), difficulty (19%) and pain during swallow (17%), preference for mushy/pasty foods (10%) and choking when eating or drinking (6%) were clinically relevant and may indicate the presence of swallowing disorders. This group also showed a higher frequency of general symptoms, such as fever, headache, abdominal pain, tiredness, diarrhea, nausea, and shortness of breath ( $p < 0.05$ ; Chi-squared test). Smell disorders, taste disorders and dry mouth were the most frequent symptoms related to the feeding behavior for both mild and severe cases. Dry mouth was significantly associated with swallowing difficulties and future research should investigate it as a frequent symptom and as a predictive of the presence of eating and swallowing disorders in COVID-19 cases.

### 1. Introduction

In 2019, a new human coronavirus emerged, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which, like other coronaviruses, has a high probability of having zoonotic origin [1,2]. The SARS-CoV-2 caused the so-called coronavirus disease 2019 (COVID-19) [3] which reached pandemic level in March 2020, posing a continuous threat to humans and the economy and leading to catastrophic consequences [4].

The new coronavirus outbreak is a major challenge for clinicians [5] and the number of confirmed cases of individuals with this virus reached high numbers worldwide [6]. It has been crucial to isolate patients, track

and quarantine contacts and educate the public about personal hygiene [7], since the basis of clinical management is symptom treatment [8]. In the absence of effective and specific pharmacological therapies [5,8], different vaccines appeared as a means of preventing infection [9,10].

The clinical course of patients has not yet been fully characterized, with some data describing the pathogenesis of the disease [5]. Besides asymptomatic individuals, there appear to be three main patterns in the clinical course of the infection: mild disease with upper respiratory tract showing symptoms; life-threatening pneumonia; and severe pneumonia with acute respiratory distress syndrome that requires advanced life support [11,12]. General symptoms include fever, cough, headache, sore throat, shortness of breath, dyspnea, rhinorrhea, chest pain, fatigue,

\* Corresponding author at: Travessa Domingos Correa, 15, 2750-332 Cascais, Portugal.

\*\* Corresponding author at: Polo da Mitra, 7002-556 Évora, Portugal.

E-mail addresses: [Contatosiphoneale@gmail.com](mailto:Contatosiphoneale@gmail.com) (A.S. Machado), [ecsl@uevora.pt](mailto:ecsl@uevora.pt) (E. Lamy).

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myalgia and confusion [7,13–21], as well as changes related to the gastrointestinal tract, such as anorexia, diarrhea, nausea, vomiting, abdominal pain and liver disorders [13,14,16,22]. Neurological symptoms were also observed, especially in patients with severe infection, including acute cerebrovascular events, encephalopathy, impaired consciousness, and skeletal muscle injury [23,24].

Other symptoms that appear to be highly related to COVID-19, and that were proposed as reliable for a specific diagnosis of the disease [25] are changes in taste and smell, like ageusia, anosmia, hypogeusia and hyposmia [17,21,26–28], as well as in chemestesis [29] that can occur before pulmonary manifestations [28] or as the only symptoms present [17,30]. Smell loss was suggested as the best predictor of COVID-19 amongst patients with symptoms of respiratory illness [31]. Moreover, evidence indicates an ability of the SARS-CoV-2 to induce gustatory disturbances, in the absence of olfactory dysfunctions, as a peculiarity of the disease [32]. The possible causes of reduced smell and taste in patients infected with COVID-19 were suggested to be the impairment of the peripheral nervous system [26] and/or the interaction of the virus with taste or smell receptors [26,28,33].

Angiotensin-converting enzyme-2 (ACE2) has been established as the functional host receptor for SARS-CoV-2 and is abundantly expressed in a variety of cells residing in many different human organs [34], including tongue mucosa and salivary glands [35,36]. SARS-CoV-2 interaction with ACE2 receptors in taste buds may impair taste sensitivity, which could induce dysfunctional gustatory responses [37], although this is still not clear, since some studies failed in identifying these receptors in the taste cells [38]. Even so, a relationship between the viral load in saliva and the severity of taste symptoms was observed [39].

Besides taste and smell impairment, some specific symptoms related to the oral cavity and feeding were also reported, namely: odynophagia [40], oral lesions [18,41–44], gingivitis [42], dry mouth [16,17,45,46] and difficulty in swallowing [45,47,48]. The importance of developing research on these specific symptoms is highlighted, since information is still scarce [41]. A review about the prevalence of oral signs and symptoms in patients with COVID-19 [41] included 40 studies from Europe, Asia and South and North Americas, with only one of them providing information about odynophagia and another one about difficulty in swallowing. None of those 40 studies investigated signs such as dry mouth, coughing during eating, choking when eating or drinking and preference for pasty foods. Therefore, the presence of signs and symptoms directly related with ingestive function, during or after infection by the Sars-Cov-2 new coronavirus, remains poorly investigated.

The present study aimed to assess the presence of signs and symptoms related to feeding behavior during and/or after the occurrence of COVID-19 in adults residing in Portugal and associate them to general symptoms and disease severity.

## 2. Material and methods

### 2.1. Participants and data collection

Data were collected between May and September 2020, by means of a questionnaire developed by the researchers to be answered online. Participants were invited through social media and email. Informed consent was obtained, and privacy rights were observed. The questionnaire contained 10 questions about general and specific symptoms before, during and after COVID-19 disease. General symptoms included the presence of fever, headache, bodily pain, abdominal pain, fatigue, diarrhea, nausea, shortness of breath, mental confusion, sore throat and cough. As specific symptoms, smell disorders, taste disorders, coughing during the meal, dry mouth, difficulty in swallowing, pain when swallowing, choking when eating or drinking, and preference for mushy/pasty foods were considered (Supplementary material).

The sample consisted of adult participants (aged between 18 and 64

years) residing in Portugal, who agreed to participate voluntarily, with a confirmed previous diagnosis of COVID-19 and who have since recovered (negative COVID-19 test) at the time of answering the questionnaire. Exclusion factors were the presence of previous neurological disorders, as well as head and neck tumors, since these conditions are related to oropharyngeal dysphagia. Patients who reported the presence of specific symptoms surveyed (smell disorders, taste disorders, coughing during the meal, dry mouth, swallowing difficulties, pain when swallowing, choking when eating or drinking, and preference for mushy/pasty foods) before the start of COVID-19 infection were also excluded.

The study received approval from the Ethical Committee of the University of Évora (Ref: GD/14848/2020).

### 2.2 Statistical analysis

Statistical analysis was performed using SPSS 27.0 software considering an alpha level of 5% by an Applied Statistics Spec (PMC). Descriptive analysis consisted of means, standard deviation and percentages. Participants who were and were not hospitalized were analyzed separately.

A two-step cluster analysis was performed to identify groups of participants with similar reported symptoms of COVID-19 during at-home therapy. The analysis included the following dichotomous variables: sex, fever, headache, bodily pain, abdominal pain, tiredness, diarrhea, nausea, shortness of breath, mental confusion, sore throat, and cough.

The final number of clusters was based on the interpretability and reliability of the cluster solution, and the differences between clusters were assessed by exploratory analysis (percentages).

Further, the generated clusters were compared using the Chi-squared test according to the reported symptoms related to the impact of COVID-19 on feeding behavior. The specific symptoms that occurred during and after the treatment of the disease were investigated.

The effect of ‘age’ on the occurrence of smell and taste disorders and dry mouth was tested using the Students’ T-test to compare the two clusters. Additionally, the association between the occurrence of taste and smell disorders and dry mouth with swallowing difficulties, pain when swallowing, choking when eating or drinking, and preference for mushy/pasty foods was assessed by means of Chi-squared test.

## 3. Results

From the 406 questionnaires received, 44 (10.83%) were not complete and were not considered in the statistical analysis. The remaining 362 participants were classified into symptomatic and asymptomatic, as shown in Table 1.

The 201 symptomatic participants presented a mean age of 39.5 years ( $\pm 10.9$ ) and median of 39 years. On average, the participants reported to be free of COVID-19 signs and symptoms for 65 days ( $\pm 44$ ).

Among the 201 symptomatic participants, 15 were hospitalized. As the stress associated with the high severity of symptoms that resulted in hospitalization can lead to low accuracy in the perception and later report of some symptoms, data from these 15 participants were evaluated descriptively and separately from other patients treated at home. This group represented 7.46% of the symptomatic participants; 10

**Table 1**  
Participants distribution according to gender, age and the presence/absence of symptoms.

	Participants	Asymptomatic	Symptomatic
<b>Gender</b>			
Female	272 (75.1%)	122 (75.8%)	150 (74.6%)
Male	90 (24.9%)	39 (24.2%)	51 (25.4%)
<b>Age</b>			
18 to 40 years old	190 (52.5%)	71 (44.1%)	119 (59.2%)
41 to 64 years old	172 (47.5%)	90 (55.9%)	82 (40.8%)
<b>Total</b>	362	161 (45.5%)	201 (55.5%)

individuals did not require mechanical ventilation, and 2 and 3 individuals required mechanical ventilation for 5 and 10 consecutive days, respectively. Patients who did not use a ventilator reported to have 5 to 11 general symptoms and those who required mechanical ventilation reported to have 3 to 12 general symptoms. Table 2 describes general and specific symptoms of the hospitalized patients.

After recovery from COVID-19, 30% of the patients who were hospitalized reported the presence of smell disorders, taste disorders and dry mouth and 10% difficulty to swallow. Those who required mechanical ventilation, 40% reported taste disorders and dry mouth after recovery and 20% difficulty to swallow.

Data from the 186 symptomatic participants who received at home therapy were analyzed using the Two-step cluster test, which generated two reliable and meaningful clusters of participants, varying according to the reported general symptoms of COVID-19. Table 3 shows the taxonomic description of the clusters, their mean age and the respective percentages of each symptom reported. Cluster 1 was labeled ‘Mild cases’ ( $n = 102$ ) and was characterized by lower percentages of reported COVID-19 general symptoms, such as headache, abdominal pain, and shortness of breath. On the other hand, Cluster 2 was labeled ‘Severe cases’ ( $n = 84$ ) and characterized by higher frequencies of COVID-19 general symptoms. The percentage of females, comparatively to males, was higher in both clusters, being slightly higher among the severe cases (77%).

Table 4 shows the comparison between clusters according to the reported specific symptoms related to the impact of COVID-19 on feeding behavior both during the treatment and symptoms after recovery. Most of the investigated specific symptoms related to feeding during the treatment showed different frequencies between clusters. The participants from the “Severe cases” cluster showed higher frequencies of smell and taste disorders, dry mouth, coughing during the meal, swallowing difficulties, pain when swallowing, and preference for mushy/pasty foods. This cluster also showed higher frequencies of the symptoms after recovery of taste disorders and dry mouth.

The mean age (years) did not differ between individuals who reported taste and/or smell disorders (mean difference = 0.25,  $p = 0.870$

**Table 2**  
Symptoms description for hospitalized patients during COVID-19.

	Hospitalized( $n = 10$ )	Mechanical ventilation( $n = 5$ )
<b>Gender</b>		
Female	10	4
Male	0	1
<b>Age</b>		
18 to 40 years	7	4
41 to 64 years	3	1
<b>General symptoms</b>		
Fever	10	4
Tiredness	10	3
Headache	9	3
Bodily pain	9	2
Diarrhea	8	3
Nausea	8	3
Cough	7	4
Shortness of breath	3	2
Mental confusion	4	2
Sore throat	4	2
Abdominal pain	6	1
<b>Specific symptoms</b>		
Smell disorders	7	3
Taste disorders	7	4
Dry mouth	4	3
Coughing during meal	4	1
Difficulty to swallow	2	1
Pain to swallow	3	1
Choking when eating or drinking	1	1
Preference for mushy/pasty foods	1	1

**Table 3**  
Taxonomic description of the clusters (mean and percentages).

	Cluster 1 mild cases	Cluster 2 severe cases
<b>Number of cases</b>	102	84
Age (mean)	39.5	39.1
Sex (females)	70%	77%
Fever	31%	59%
Headache	25%	92%
Bodily pain	36%	94%
Abdominal pain	3%	24%
Tiredness	28%	83%
Diarrhea	21%	60%
Nausea	4%	35%
Shortness of breath	2%	30%
Mental confusion	1%	14%
Sore throat	21%	62%
Cough	33%	64%

**Table 4**  
Comparison of the clusters according to the specific symptoms related to the impact of COVID-19 on nutrition (%).

	Cluster 1 mild cases $n = 102$	Cluster 2 severe cases $n = 84$
<b>During treatment</b>	%	%
Smell disorders	40*	62*
Taste disorders	37*	60*
Coughing during the meal	9*	31*
Dry mouth	23*	48*
Difficulty to swallow	8*	19*
Pain to swallowing	6*	17*
Choking when eating or drinking	1	6
Preference for mushy/pasty foods	1*	10*
<b>After recovery</b>	%	%
Smell disorders	18	27
Taste disorders	15*	30*
Coughing during the meal	2	8
Dry mouth	13*	26*
Difficulty to swallow	3	4
Pain to swallowing	2	4
Choking when eating or drinking	0	1
Preference for mushy/pasty foods	1	1

\* $p < 0.05$  (Chi-squared test).

and mean difference = 1.96,  $p = 0.205$ , respectively), with no sex difference ( $p > 0.05$ ). However, when examining the difference of age between individuals who reported and individuals who did not report dry mouth symptoms, a significant difference was observed during the course of the disease ( $p = 0.018$ ), but not after the treatment ( $p = 0.103$ ) and with no sex differences in any of the periods ( $p > 0.05$ ). The individuals who reported symptoms of dry mouth showed a mean age of 42 years ( $\pm 10$ ), while the other individuals showed a mean age of 38 years ( $\pm 11.2$ ).

Additionally, significant association was found between the occurrence of dry mouth during the course of the disease and the occurrence of swallowing difficulties, pain when swallowing, choking when eating or drinking, and preference for mushy/pasty foods ( $p < 0.01$ ) in both groups, mild and severe cases.

The occurrence of taste and smell disorders was associated with dry mouth symptoms during the course of the disease ( $X^2 = 9.7, p = 0.002$  and  $X^2 = 7.2, p = 0.007$ , respectively). On the other hand, no significant associations were found between the occurrence of taste and smell disorders and swallowing difficulties, pain when swallowing, choking when eating or drinking, and preference for mushy/pasty foods during the course of the disease ( $p > 0.05$ ).

#### 4. Discussion

When starting the discussion, it is important to note that comparisons with the literature are limited, since the studies differ in crucial aspects such as age, associated comorbidities, severity of cases, and methodology of data collection.

The sample characteristics of the present study indicate most female cases (75.14%), similarly to findings in Canada (52.2%) [20], while the General Directorate of Health of Portugal (DGS) reported 54.62% of female cases in the same period [49]. It is noteworthy that the research was carried out with spontaneous participation, which could indicate a greater interest by women in collaborating with this type of research.

Asymptomatic cases represented 45.5% of the participants and literature shows inconsistent data, with 50.5% of asymptomatic cases reported in Japan [50], 44.8% in Italy [51], 42.3% in China [52], 19.22% in Korea [53], 3.5% in Brazil [54], and DGS does not indicate this data for the period in Portugal [55]. The screening of non-symptomatic and suspected cases is complex and varies across different countries [56]. Asymptomatic infections are an important aspect of COVID-19 disease [57], and the estimation of the asymptomatic ratio can improve the comprehension of disease transmission [58], since evidence suggests that non-symptomatic individuals can spread COVID-19 [57,59]. There was no sex difference, but considering age, asymptomatic cases showed to be concentrated between 41 and 64 years old (55.90%) and among symptomatic participants the predominance of cases was from 18 to 40 years (59.20%). These data diverge from the statement that the risk of symptomatic infection increase with age [52, 60], 4% per year among adults aged 30–60 years old [60].

The hospitalized patients, aged 26–64 years, represented 7.46% of the symptomatic participants of this study. This group consisted mainly of women, corroborating a study developed in Brazil (68.1% female) [54], but differing from those which found a predominance of males in hospitalized cases conducted in China (54.3%) [14], Canada (63%) [61], USA (75%) [19] and Italy (82%) [62]; the age of the participants in those studies ranged from 22 to 92 years and included individuals with several comorbidities that were excluded in the present study. The most common general symptoms referred by the hospitalized patients were fever, tiredness, headache and cough, and in previous studies the most frequent symptoms were cough, tiredness, shortness of breath, myalgia and fever [14,19,54,61,63]. Smell and taste disorders were reported by 70% of hospitalized patients, a higher frequency than that reported in the literature (between 19% and 48.7%) [19,21,45,64]. Dry mouth was reported by 30% of the hospitalized patients and by 40% of whom requested mechanical ventilation, similarly to previous findings (30%) [45]. Swallowing difficulties were reported by 30% of the participants, and even after recovering from COVID-19, 10% of the patients that were hospitalized and 20% of those who required mechanical ventilation reported swallowing difficulties, and this aspect should be included in the investigation of hospitalized COVID-19 cases with or without the use of mechanical ventilation.

The symptomatic participants who received at home therapy were classified as 'Mild cases' and 'Severe cases' clusters according to the reported general symptoms of COVID-19. Among the 'Mild cases', the most common symptoms were fever and cough, similar to a Korean study [53] that included only mild cases and reported 'cough' as the main symptom related to COVID-19. Among the 'Severe cases', the most common general symptoms reported were shortness of breath, mental confusion, nausea, abdominal pain and headache. In general, there is evidence in the literature that the most frequent symptoms are fever, cough, myalgia, headache and tiredness [27,46,48,53,54,65,66], with high incidence of specific symptoms related to feeding behavior also reported. In the present study, the main symptoms related to feeding behavior observed in both mild and severe cases were smell disorders (40% and 62%), taste disorders (37% and 60%) and dry mouth (23% and 48%), respectively.

The prevalence of smell disorders reported in the literature varies

from 39.5 to 92% [17,20, 27,30,36,42–44,49,60,62–67,], as well the prevalence of taste disorders, which varied from 27 to 89% [15,17,20, 27,40,46–48,64,66–68,70]. While no age or sex effects on the frequency of taste and/or smell disorders was observed in the present study, the literature suggests that these symptoms are more prevalent in females [40,47,69]. It should be noted that the mentioned studies did not distinguish the severity of the cases, and involved participants of varying ages, including the elderly.

Dry mouth was referred by 23% of the mild cases and 48% of the severe cases and although there was no difference between males and females, the prevalence was higher in older participants. This symptom was also reported in previous studies, with variable prevalence from 32 to 52.2% [15,17,46]. It is worth mentioning the small number of studies that investigated the presence of dry mouth during COVID-19 disease, although SARS-CoV-2 has been detected in whole saliva and in the saliva collected from the opening of the salivary glands duct [15,33,35,72,73]. It has been shown that salivary gland epithelial cells are early targets of SARS-CoV2 and salivary gland functions may be affected [16,36,73], suggesting a relation between the oral symptoms and the reduced salivary flow [46]. In line with the known effects of dry-mouth in feeding aspects [74,75], significant association was found between the occurrence of dry mouth during the course of the disease and the reported difficulty to swallow, pain to swallow, choking when eating or drinking, and preference for mushy/pasty foods. This evidence in COVID-19 pathology, with the consequent food-related effects that it may have, highlights the relevance of including dry-mouth in future researches and even in COVID-19 diagnosis.

The occurrence of taste and smell disorders was associated with dry mouth symptoms during the course of the disease, confirming previous findings [17]. The known relationship existent between salivary flow rate and saliva composition with taste sensitivity [76,77] may be an explanation. No significant association was found between the occurrence of taste and smell disorders and swallowing difficulties, pain when swallowing, choking when eating or drinking, and preference for mushy/pasty foods during the course of the disease, which suggests that taste and smell disorders was not related to feeding difficulties.

For the 'Severe cases' group, the incidence of coughing during the meal, difficulty and pain to swallow, preference for mushy/pasty foods and choking when eating or drinking are relevant and could represent the presence of swallowing difficulties during the course of COVID-19, even in severe cases who were not hospitalized.

It is important to highlight the persistence of symptoms after recovering from the disease, particularly smell disorders (18–27%), taste disorders (15–30%) and dry mouth (13–26%). The literature reported that smell disorder remained after disease recovery in 10–18% in Italy [46,68] and 3.3% in Europe [47], while taste disorders persisted in 8–15% of the participants after recovering from the disease [46,68]. Studies that investigated the persistency of dry mouth after recovering from COVID-19 were not found. Coughing during meal, pain during swallowing and difficulty to swallow presented lower rates (4–8%) that confirm literature evidence [48], and should also be consider.

The limitations of the study include the assessment of aspects whose understanding may vary slightly between people, as smell and taste disorders, or even dry mouth feeling. Moreover, this questionnaire was based on the participants' report about what they felt during the period they were infected, rather than on evaluation at the moment of symptoms. The use of an online questionnaire reaches a group of individuals that may be more used to technological equipment. Finally, the sample was restricted to adults, so conclusions cannot be extrapolated to other ages.

#### 5. Conclusions

This study allows us to conclude that different symptoms that may affect oral processing and ingestion are present in a considerable proportion of individuals infected with SARS-Cov-2. The prevalence of



these symptoms appears to be clinically relevant and associated to the severity of the disease.

In line with other studies, the most frequent symptoms related to feeding behavior were smell disorders and taste disorders, with dry mouth also appearing as an important symptom, for both mild and severe cases during the course of the disease and after recovering. Dry mouth was significantly associated to difficulty to swallow, pain to swallow, choking when eating or drinking, and preference for mushy/pasty foods, what points to the importance of monitoring these symptoms to avoid patients' poor nutrition. The results highlight the relevance of confirming dry-mouth as a clinical characteristic and frequent symptom of COVID-19 in future studies. Considering dry mouth symptomatology, together with recent studies showing an action of the virus at salivary gland level, further studies searching for the effect of the COVID-19 on saliva flow rate and biochemical composition of saliva are of interest.

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### Identification

Age:

Did you have a diagnosis of Covid-19?

Yes

No

Previous illnesses:

Neurological disorders (Parkinson's Disease, Stroke, Amyotrophic Lateral Sclerosis, Multiple Sclerosis)

Head or neck tumors

1) Regarding Covid-19 disease, at the moment you are:

cured of Covid-19 and had no symptoms during the disease

cured of Covid-19 and had only mild symptoms during the disease

cured of Covid-19 and was hospitalized during the illness, but without using a ventilator

cured of Covid-19 and was hospitalized during the illness, using a ventilator for up to 5 days

cured of Covid-19 and was hospitalized during the illness, using a ventilator for more than 5 days

2) How long have you been without Covid-19 symptoms (shortness of breath, cough, fever, headache, body pain):

I had no symptoms of Covid-19

0 to 15 days

15 to 30 days

30 to 60 days

Between 60 and 120 days

More than 120 days

3) Before being infected, did you have any of the symptoms below?

Frequent choking while eating (at least once a day)

Cough during or after eating

Tiredness during or after eating

Modification of food consistency with a preference for pasty foods

Difficulty for swallowing

Difficulty for eating, making meals take too long

Pain to swallow

Dry mouth sensation

Reduction in the amount of saliva

Reduction in taste, less taste of food

Reduction in smell, less smelling of food

4) During the period you were with Covid-19, did you have any of the symptoms below?

Frequent choking while eating (at least once a day)

Cough during or after eating

Tiredness during or after eating

Modification of food consistency with a preference for pasty foods

Difficulty for swallowing

Difficulty for eating, making meals take too long

Pain to swallow

Dry mouth sensation

Reduction in the amount of saliva

Reduction in taste, less taste of food

Reduction in smell, less smelling of food

5) After the period you were with Covid-19, did you present any of the symptoms below?

Frequent choking while eating (at least once a day)

Cough during or after eating

Tiredness during or after eating

Modification of food consistency with a preference for pasty foods

Difficulty for swallowing

Difficulty for eating, making meals take too long

Pain to swallow

Dry mouth sensation

Reduction in the amount of saliva

Reduction in taste, less taste of food

Reduction in smell, less smelling of food

### Declaration of Competing Interest

The authors declare no conflict of interest.

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