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Psychological Correlates of Post-COVID Condition

Mária Giertlová [1]
Claudia Misofová [2]

[1] University of Ss. Cyril and Methodius, Trnava, Slovakia
giertlova1@ucm.sk
https://orcid.org/0000-0003-0290-6570
[2] University of Ss. Cyril and Methodius, Trnava, Slovakia
misofova2@ucm.sk

Abstract: *This article deals with psychological correlates of the post-COVID condition - depression, anxiety, and memory problems including remembering and forgetting. The work has a longitudinal character, while it examines the post-COVID condition in a group of participants based on infection of the disease Covid-19. At the same time, participants who never had this disease (N=86, for the 1. measure and N=38 for the 2. measure) are compared with those who were infected with COVID-19 (N=112, for the 1. measure and N=36 for the 2. measure), while participants were separated for analysis in groups based on the time from infection. Group of respondents who were infected within 3 months, from 3-9 months from infection and 9+ months since infecting with the disease. We used tests for comparison, such as the Kruskal Wallis test and multivariate procedures for within-subject and between-subject changes, using Anova for mixed experimental designs. We also determined the risk of being included in a group based on the time of infection with COVID-19 through multinominal logistic regression. We found differences in all variables in general between those infected with COVID-19 and those not. In neuropsychiatric aspects- anxiety and depression were confirmed cyclical features in those who were infected with COVID-19 in time, with the worst value of variables in the group from 3-9 months from infecting with the disease. In the current memory scale and its subscale, the act of remembering was a value that worsened over time and it was confirmed as an effect of group inclusion.*

Keywords: *post-covid condition; anxiety; depression; memory*

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1. Introduction

As the COVID-19 pandemic has progressed, there has been a growing amount of disturbing knowledge about the more complex health impacts of the disease. The global pandemic of Covid-19 has deeply affected people's lives. People infected with the disease have experienced a worsened psychological state, not to mention the symptoms that can develop after infecting with Covid-19 itself.

Clinical psychology practice shows that, in addition to the usual cases and cases understandably related to the unpleasant consequences of the pandemic, clinical psychologists are also seeing an increase in unusual cases, which they have encountered only very rarely and which can be assumed to be directly related to the infecting with Covid-19. For these patients who do come in, there has been no history of psychological or psychiatric care. They had an unproblematic history on the side of mental disorders until the time of infection with Covid-19 disease. Based on these cases, experts are wondering about the issue of the association of viral illness and its impact on mental health (Lečbych, 2021).

It is estimated that approximately 10% to 20% of people who have been infected with SARS-CoV-2 will develop long Covid which represents symptoms persisting beyond 3 months after infection. Crucially, the prevalence rate of the post-COVID state may be difficult to determine due to the temporal difference between infection and symptoms of long-term COVID-19 and the presence of multimorbidity. Another fact is that there is insufficient information on the clinical manifestations, risk factors, and underlying mechanisms of long-term COVID-19 (Bueno-Guerra, 2022).

Given the overwhelming number of studies, a broad vision is preferred by selecting systematic reviews, meta-analyses, and longitudinal research over nationally specific studies. However, this strategy does not ensure the provision of causal or relational evidence given that most studies conducted and published to date are not longitudinal or prospective, and therefore even systematic reviews may be biased in their conclusions. The heterogeneity of research samples and procedures hinders generalizability, and there is also a lack of comparisons with control groups (Bueno-Guerra, 2022).

2. Post-covid condition-definition and definitions

Conceptual definition of post-covid-19 phases according to Shah et al. (2021):

- Acute covid-19 infection-signs and symptoms of covid-19 for up to 4 weeks
- Persistent symptomatic covid-19 - signs and symptoms of covid-19 are present from 4 weeks to 12 weeks
- Post-COVID-19 syndrome - signs and symptoms that develop during or after infection consistent with COVID-19 last longer than 12 weeks and cannot be attributed to alternative diagnoses (Shah et al., 2021).

There is evidence that symptoms of mild COVID-19 persist after 3 weeks in one-third of patients. However, data on symptoms persisting beyond 3 months (long Covid) are lacking. Persistent symptoms can be divided into physical, psychological, and social symptoms. The distinction between post-acute and long-term COVID-19 is somewhat arbitrary, but it is important to distinguish between phases for a better understanding and explore the implications of COVID-19 in the short and long term (Kessel et al. 2022). As with patients after acute Covid-19, patients with long-standing Covid may experience a reduction in psychological and cognitive functioning. In a study by van den Borst et al. (2020 in Kessel et al., 2022), abnormal scores on various mental and cognitive health questionnaires were observed in approximately 10% of patients after a mean follow-up of 13 weeks. Normal scores for all questionnaires used were found in only 59% of participants (Van der Brost, 2020 in Kessel et al., 2022).

The prevalence of cognitive and affective psychiatric features, such as memory deficits and anxiety-depressive symptoms, has been reported to increase over time. Such a peculiar pattern of symptom trajectories is thought to suggest that psychiatric symptoms are more likely to develop post-infection rather than simply persisting as a residual component of the acute phase (Colizzi et al., 2022). The results in this study support previous evidence of an increase in long-term affective and cognitive symptoms in patients who were infected with Covid-19, which is characteristic of the acute phase of Covid-19. The findings of this study are novel in demonstrating an association between persistent symptoms related to multiple physical symptoms and increasing affective and cognitive symptoms at follow-up over time. Evidence-based data suggest greater psychological distress six or more months after infection, compared with weeks immediately after viral positivity. However, it is still unclear when and whether to expect such symptoms to plateau and begin to diminish. There are also few studies in the literature addressing risk factors for post-Covid syndrome. Therefore, efforts are needed to increase knowledge about the determinants of post-Covid-19 syndrome, particularly concerning psychiatric manifestations, to mitigate the risk of potentially irreversible low adjustment, low quality of life, and reduced overall well-being (Colizzi et al., 2022).

3. Neurobiological and neuropsychological aspects of Covid-19

After the acute phase of the disease, which is usually dominated by respiratory symptoms, further psychoneuroimmunological symptoms come with the progression of weeks to months, and their consequences fully manifest with a delay. The impingement on the integrity of the CNS naturally carries the risks of various types of neuropsychological deficits. With the greatest frequency, conditions classifiable corresponding to mild cognitive impairment are described (Troyer et al. 2020).

The findings highlight that cognitive deficits are not limited to patients who had long-term neurological manifestations after recovery (Graham et al. 2022, in Zhao et al., 2022), but may also exist in a subclinical form among Covid-19 survivors. This suggests that these functional deficits may not be apparent in patients with milder COVID-19 disease (Zhao et al., 2022).

Some previous studies have observed significant recovery of cognitive function over time (Zhao et al., 2021) and other recovery of brain function observed through imaging devices (Blazhenets et al., 2021, in Hampshire et al., 2022). However, they conclude that any recovery of cognitive abilities will be slow at best (Hampshire et al., 2022). It is important to note that neuropsychiatric disorders may be underdiagnosed or undiagnosed and may contribute significantly to a more severe course of COVID-19, hospitalization, and mortality (Adhikari et al., 2020).

4. Anxiety and depression after overcoming Covid-19

States of anxiety, depression, and insomnia were the first symptoms observed since the first wave of the pandemic. Since then, patients with these types of problems have been increasing. Some patients have already been stabilized, e.g., patients with five-year episodes of remission of anxiety disorders, who report a reappearance of anxiety problems, OCD symptoms, panic attacks, and social anxiety after COVID-19 (Lečbych, 2021).

Findings suggest that a significant proportion of COVID-19 patients may experience psychiatric morbidity in the first months after infection. This is consistent with the results of previous research on SARS and MERS outbreaks, which reported 10% to 35% psychiatric morbidity in the post-disease stage (Poyraz et al., 2021). While delirium, insomnia, symptoms of depression, anxiety, and PTSD have been reported as common features in the acute period of COVID-19 infection, few studies examine long-term psychological status (Rogers et al., 2020). Mazza et al. (2022) report that more than half of subjects with prior COVID-19 infection had clinically significant anxiety, depression, PTSD, and/or obsessive-compulsive symptoms, at nearly one-month post-treatment hospital follow-up. Similarly, Liu et al. (2020) found that "moderate to

severe" depression and anxiety were approximately 10% and 20%, respectively, approximately one month after hospital discharge (Liu et al., 2020).

5. Research problem

The research problem is highlighted by studies where we can see unclear results after infection with COVID-19 in the long term in longitudinal studies of measures of depression, anxiety, and memory. The discrepancy is present in longitudinal studies, the results of which vary in the prevalence and severity of psychological correlates of the post-covid state, where these difficulties lasted for a period of 3 months (e.g. Stein, 2022, Poyraz et al., 2021, Bourmistrova et al., 2021) and others longer (Colizzi et al., 2022). Some describe the cyclical nature of the condition, where some symptoms improve while others worsen (Berrenguera, 2021). The work aimed to find out the differences in the respondents based on time since the COVID-19 infection and to find out the differences between the 1st and 2nd measurements in psychological correlates of depression, anxiety, and memory in the Slovak population.

6. Methods

6.1. Research sample

Respondents were selected by non-probability, purposive sampling. The total number of respondents was N=198. Data {{{were collected in Slovakia. Patients who were treated in outpatient clinics after COVID-19, as well as those who subjectively experienced a change in their health status after overcoming the disease of COVID-19, were included in the research. We categorized respondents with post-covid status, based on time since infection with Covid-19, according to which categorization yielded a normal distribution. In the first measurement, N=86 (43.9%) were those who never had COVID-19, N=40 (20.4%) was the number of respondents who were infected within 3 months, from 3-9 months from infection was N=44 (22.4%) and 9+ months since infecting with the disease was N=26 (13.3%). The age of respondents was 18-60 years (M=39,13, median=39.5 and modus=26), with N=160 (81.6%) females and N=36 (18.4%) males.

6.2. Data collection methods

To measure depression, we chose the DASS-42, which is a self-report scale for measuring negative emotional states: depression, anxiety, and stress. For the research, we chose only the depression scale. This scale consists of 14 items where the respondent answers on a 4-point Likert scale where 0= not true for me at all to 3= true for me completely or most of the time (Lovibond, Lovibond, 1995). This scale was tested in Slovakia for psychometrical properties by Hajdúk and Boleková (2015) with sufficient results of validity and reliability.

Memory was measured using the Scale of current memory, which measures remembering and forgetting separately and those scales together as a result of the current memory of patients. For forgetting we used 29 items, thus the maximum score that the respondent can achieve is 145 and for remembering the maximum score is 105 for 21 items. It is answered on a 5-point Likert scale and the highest score indicates the best state of memory. This method has reliable psychometrical properties and it is the only self-report scale to measure memory in Slovakia (Ruisel, Mullner, & Farkas, 1986).

The STAI questionnaire is designed to measure anxiety and anxiousness. The response is measured on a Likert scale, with 1= not at all, 2= just a little, 3= quite a bit, and 4= very much. The higher the score, the higher the degree of anxiety and anxiousness (Mullner, Ruisel, & Farkaš, 1980).

6.3. Procedures

At first, we tested out the research sample for normality. According to several respondents, we chose the right test for normality results. We divided respondents who overcame the disease COVID-19 according to normality in the subgroups, with the best normality results in all variables and subgroups. Therefore they were divided into groups: up to 3 months since infection, from 3-9 months since infection, and 9+ months since infection. First, we compared cross-sectionally those who never had the disease with those who were infected while divided into mentioned groups in depression and anxiety. We used the non-parametric Kruskal Wallis test because normality distribution was not observed in all groups. After all conditions for multivariate testing were met, we tested the current memory and remembering in respondents. When testing the difference between the first and second measurements, we investigated whether the odds ratio increases the risk of being included in groups based on time since infection with the COVID-19 disease using multinominal logistic regression with predictor of the degree of difference between the first and second measurement (measurement 2- measurement 1). To see size effects and their interactions we used multivariate Anova for the mixed experimental designs.

7. Results

H1: We hypothesize a statistically significant difference in anxiety as a state in the groups due to time since infection with COVID-19 (within 3 months, within 9 months, and 9+ months after infection) and those who never had this disease.

H1a: We hypothesize a statistically significant difference in anxiousness in the groups due to time since infection with COVID-19 (within 3 months, within 9 months, and 9+ months after infection) and those who never had this disease.

Table 1. Kruskal Wallis test, comparison of several groups due to time since infection with COVID-19 in the variables anxiousness and anxiety as a state

Respondents in categories by time from infection		N	Average ranking	Kruskal Wallis test	
Anxiousness	Never had Covid-19	86	81,76	Chi-squared	14,462
	Within 3 months	40	108,70	Df	3
	within 9 months	44	118,27	Sig.	**0,002**
	9+	26	104,73		
	Total	196			
Anxiety as a state	Never had Covid-19	86	82,43	Chi-squared	13,412
	Within 3 months	40	107,45	Df	3
	within 9 months	44	117,91	Sig.	**0,004**
	9+	26	105,04		
	Total	196			

Hypothesis H1 and sub-hypothesis H1a were tested using the non-parametric Kruskal Wallis test for 3 or more samples. We chose the non-parametric version, as the normal distribution of variables was not observed in all subgroups. The results are presented in Table 1. The result of the Kruskal Wallis test for the variable anxiety as a state (H1), with test result X2=13.412, df=3, and sig.<0.05. The result is statistically significant, which means that there is a difference in the variable anxiety as a state between respondents based on time since infection with COVID-19, therefore, we accept the H1 hypothesis.

The anxiousness variable was also compared in groups using the non-parametric Kruskal Wallis test, with X2= 14.462, df=3, and statistical significance at sig.<0.005 level. Again, the difference between the groups was confirmed, therefore, the partial hypothesis H1a is accepted. There is a statistically significant difference in the variable anxiousness in the subgroups based on time since infection.

As we can see in Table 1, in all variables, the mean rank (MR) is lowest in the „never had Covid-19“ group and highest in the group, within 9 months since infection with the disease.

H2: We hypothesize a statistically significant difference in depression in the groups due to time since infection with COVID-19 (within 3 months, within 9 months, and 9+ months after infection) and those who never had the disease.

Table 2. Kruskal Wallis test, comparison of several groups due to time since infection with COVID-19 in the depression variable

Respondents in categories by time from infection		N	Average ranking	Kruskal Wallis test	
depression	Never had Covid-19	86	83,41	Chi-squared	11,221
	Within 3 months	40	108,45	Df	3
	within 9 months	44	113,77	Sig.	**0,011**
	9+	26	107,27		
	Total	196			

Statistical analysis presented in Table 2 showed a statistically significant difference (sig.<0.05) between the respondents on the variable of depression with Kruskal Wallis test value X2=11.221, degrees of freedom df=3. We accept the hypothesis H2 as there is a statistically significant difference among the respondents. The lowest depressivity value is for the group of those who never had COVID-19 (MR=83.41) and the highest value is for the group within 9 months since infection (MR=113.77).

RQ1: Does the difference between measurements of psychological correlates (current memory and remembering) predict the risk of inclusion in the group due to time since infecting (never had COVID-19, within 3 months, within 9 months after infecting and 9+ months after infecting) with the disease of Covid-19?

In the first research question (RQ1), we asked whether the difference between the measurements increases the odds ratio/predicts the risk of inclusion in the groups within 3 months since infection, within 9 months, and 9+ months after infection, while the reference group is represented by respondents who never had Covid-19. We obtained the results through multinomial logistic regression analysis using the ENTER method. The dependent variable is categorical - respondents based on time since infection with COVID-19 disease, with the reference category never had COVID-19 and the independent variable, the predictor is the variance/difference between the 1st and 2nd measurement of psychological correlates.

Table 3. Results of multinomial logistic regression analysis using the ENTER method; dependent variable: categories of time since infecting with COVID-19 with the reference group never had the disease and the predictor difference between the 1st and 2nd measurement in remembering

Difference in remembering	Chi-squared 19,746	Df 3	Sig. 0,000			
	-2 log-likelihood 125,992	Cox and Snell R2 0,234	Nagelkerke R2 0,257			
	B	S.E	Wald	Df	Sig.	Exp(B)
within 3 months	0,212	0,064	11,047	1	**0,001**	1,237
within 9 months	0,184	0,061	9,032	1	**0,003**	1,202
9+ months	-0,112	0,068	2,706	1	0,1	1,119

Reference category: never had Covid-19

The statistical analysis presented in Table 3 shows the results using multinomial logistic regression analysis. The dependent variable was the group of respondents based on time since

infection with the disease COVID-19 (within 3 months since infection, within 9 months, and 9+ months since infection with the disease) and the predictor was the difference in remembering between measurements. The dependent variable has values 0, 1, 3, and 5, where the value 0 is the reference group of respondents that never had the disease and 1, 3, and 5 are the phenomena we are examining compared to the reference group. The model as a whole is valid as it reaches statistical significance (sig<0.001). In Table 3, we can see one statistical result with sig.>0.05 (sig.= 0.1), which means that the difference in remembering does not increase the odds ratio of being included in the group of respondents 9+ months since infection with COVID-19 compared to the reference group of respondents who never had the disease. The predictor explains the 23.4 (Cox and Snell) -25.7% (Nagelkerke) chance of grouping. Based on significance (sig.=0.001) we can see that the ratio of inclusion in the group is statistically significant in the group within 3 months since infection. The value of the odds ratio Exp(B) is 1,237. The more the independent variable, which is represented by the variance between measurements in remembering (higher variance means worsened memory), the higher the odds ratio of being included in the group infected with COVID-19 within 3 months.

Another significant result applies to the group of respondents who were infected with COVID-19 within 9 months. Statistical analysis pointed to a statistically significant result at the significance level of sig. <0.05. The coefficient Exp(B)=1.202 explains the value of the odds ratio that the respondents belong to the group that was infected with COVID-19 within 9 months. A positive value means that the more the independent variable, represented by the difference between the remembering measures, the higher the probability that the respondents will belong to this group. The answer to the research question will be that the predictor variance between remembering measures (higher value, worse remembering) has a predictive value for the groups: within 3 and 9 months since infection with COVID-19 compared to the reference group that never had COVID-19.

Table 4. Results of multinomial logistic regression analysis using the ENTER method; dependent variable: categories of Covid-19 due to time since infecting with the reference group never had Covid-19 with the predictor difference between the 1st and 2nd measurement on the current memory scale

Difference in current memory scale	Chi-squared 9,109	Df 3	Sig. 0,028			
	-2 log-likelihood 145,824	Cox and Snell R2 0,116	Nagelkerke R2 0,127			
	B	S.E	Wald	Df	Sig.	Exp(B)
within 3 months	0,049	0,025	4,068	1	**0,044**	1,102
within 9 months	0,063	0,025	6,430	1	**0,011**	1,118
9+ months	0,020	0,031	0,439	1	0,507	1,083

Reference category: never had Covid-19

The results presented in Table 4, show the predictor difference in the current memory scale between measurements with the dependent variable groups of respondents based on time since infection with COVID-19. This assumption was also verified through multinomial logistic regression analysis. In this case, the reference group has also never had a disease like Covid-19. In the table, we can see two statistically significant predictors. There is no significant result for the group 9+ months since COVID-19 infection based on the odds ratio with predictor difference in the current memory scale. The predictor explains from 11.6%- 12.7% of the odds ratio, and the model is statistically significant with a sig. value <0.05 and a Chi-square result of 9.109. The significance value for the group within 3 months since infecting is less than 0.05 (Sig.=0.044), with a positive coefficient (Exp(B)=1.102), which increases the odds ratio for inclusion in this group in comparison to the reference group based on the predictor-difference in the current memory scale. The more the independent variable, in this case, the greater the difference between the memory measures, and the higher the odds ratio of being included in the group infected with COVID-19 within 3 months.

Another significant result applies to the group within 9 months since infection with COVID-19 (sig.<0.05, Exp(B)=1.118). The greater the variance between memory measures, the higher the odds ratio of being included in this group (9 months since infection with COVID-19) compared to the reference group never had COVID-19. The answer to the research question will be that the predictor of the variance between measures of the current memory scale has predictive significance for the groups: within 3 and 9 months since infecting with COVID-19 compared to the reference group who never had COVID-19.

RQ2: Is there an effect of time and group inclusion due to categories of time since infection with COVID-19 in the psychological correlate of remembering in measures 1 and 2?

We answer the research question using Anova's statistical test for mixed experimental designs. We analyzed the variables for which the normality of the difference between the subgroup measurements is confirmed.

Table 5. Anova for mixed experimental designs, the effect of time and group inclusion on remembering based on time since infection with COVID-19

Box´s M	12,458							
Sig.	0,242							
Categories No. measures	Never had Covid-19 (1)	within 3 mo. (1)	within 9 mo.(1)	9+ mo.(1)	Never had Covid-19 (2)	within 3 mo.(2)	within 9 mo.(2)	9+ mo.(2)
Average	74,421	78,714	80,428	61,500	76,578	73,428	76,142	59,750
Std. deviation	9,925	9,474	9,279	5,371	9,958	7,977	10,06	9,30
effect					value	F	Sig.	Eta^2
time		Wilk´s Lambda			0,899	7,853	**0,007**	0,101
time* group inclusion					0,763	7,253	**0,000**	0,237

Multivariate statistical analysis using Anova for the mixed experimental designs is presented in Table 5. We examined the effect of time and group inclusion on measures 1. and 2. in the remembering variable due to time since infection with COVID-19. The result of Box's test has a statistical significance value greater than 0.05, indicating that the equality of covariance matrices is maintained.

According to statistical significance, we can see that the effect of time between measurements is statistically significant (sig.<0.05) with the value of F=7.853 the coefficient of Wilk's lambda of 0.899, and the strength of the effect is 0.101. There is a slightly larger effect in the interaction of time and group inclusion at the sig.<0.001 level of statistical significance, F=7.535, with an effect size of 0.237. Based on the results, we can interpret that the difference between the 1st and 2nd measures of remembering is affected by time and the interaction of time and group inclusion.

8. Discussion

Hypotheses investigating anxiety and depression were formulated based on assumptions that claimed that increased anxiety and depression may be present in the general population (Bueno-Guerra, 2022, Stein, 2022). On the other hand, Stein (2022) and Rogers et al., (2020) found that patients recovering from Covid-19 are at higher risk for neuro-psychiatric symptoms and disorders, including anxiety and depressive disorders. Differences in anxiousness and anxiety as a state were formulated in hypothesis one and its sub-hypothesis H1a, where we assumed a difference in these variables between respondents (those who never had Covid-19 and those who were infected with Covid 19). A statistically significant difference was demonstrated in all variables, therefore we

confirmed the hypotheses. In all variables, those who never had Covid-19 had the lowest average rank, which means, they had the lowest anxiety level. The highest average rank was in the group that was infected with Covid-19 disease for 3 to 9 months. Linked to this hypothesis is a hypothesis that examined depression between groups. Again, a statistically significant difference was demonstrated between the groups with the lowest depression in those who never had Covid-19 and the highest in the group from 3 to 9 months after infecting with Covid-19.

Even in this cross-sectional comparison, we can see differences between groups. We found that within 3 months of infection, there is increased anxiety and depression, which may be related to neuro-psychological aspects (Mazza et al., 2022), the value of which still increases during half a year and then decreases a little and equalizes approximately to the value as after the infecting within 3 months. Similar findings were made by authors where the presence of depression and anxiety lasted longer than 3 months (Colizzi et al., 2022). In the research problem we expressed the aforementioned discrepancy because in other longitudinal studies, the severity of these psychological correlates of post-covid status: depression, anxiety, and worsened memory persisted for 3 months (e.g., Stein, 2022; Poyraz et al., 2021; Bourmistrova et al., 2021). The last group due to time since infection with Covid-19 in our research set consisted of respondents 9+ months after infection and their anxiety and depression values are still higher than those who never had Covid-19, which is noteworthy (remarkable). In this case, we don't know at all if and when they will reach the same values as the general population of those who never had this disease. Even Kingstone et al. (2020 in Kessel et al., 2022) report that some patients express concern that full recovery may not be possible. In the Ladds et al. study, (2020 in Kessel et al., 2022) patients expressed that they felt like they were in a cycle of improving and deteriorating health, which is also indicated by our results.

In the first research question, we investigated the predictive significance of the difference between measurements 1 and 2 on the risk of inclusion in the group due to time since infecting (within 3 months, within 9 months since infecting, and 9+ months since infecting) with disease Covid-19. The reference group was respondents who never had COVID-19. In the individual psychological correlates, the difference between the measurements was taken into account, while we tested the odds ratio/ the risk of being included in the group, which was confirmed in remembering in the groups of COVID-19 disease: within 3 months since infection with Covid-19and from 3 to 9 months since infecting. This means, that the greater the difference between measures in remembering (worsened remembering), the greater the probability that respondents will belong to these groups (within 3 months and within 3 to 9 months since infection) compared to those who never had Covid-19. This same odds ratio was confirmed in the same groups in the current memory scale (remembering + forgetting).

To further answer the research question, we used multivariate analysis of variance ANOVA for mixed experimental designs. The effect of time was calculated, the time factor, which causes a change between the 1st and 2nd measurement and between subjects is the inclusion in the group (never had COVID-19, within 3 months since infection, 3-9 months since infection with the disease and 9+ months since infecting with Covid-19). A statistically significant analysis was valid for remembering, where the effect of time itself between the groups was confirmed, as well as the interaction of the effect of time and belonging to the group. Not only remembering values are different in the individual measurements (worse in the second measurement for the post-covid ones), but they are also different in the cross-sectional comparison of the groups, where only the original group that was infected with the disease within 3 months scored worse compared to the control group in the 2nd measurement.

Since the research area has not yet dealt with remembering itself, we can interpret the result with a comparison of overall changes in memory and cognitive functions in patients with a post-covid condition**.** Guo et al. (2022) found that COVID-19 infection (regardless of ongoing symptoms) was associated with reduced performance on a factor created from variable memory tasks, but not with other cognitive task factors. This finding supports our results in that our research

group consisted not only of patients who were predicted to be symptomatic but also of respondents who subjectively experienced a change in their health status after infecting with COVID-19. Regarding the developmental aspect of cognitive deficit, Troyer et al. (2020) describe that neurocognitive deficits appear after the acute phase (after 3 months), as indicated by our Anova results, while impaired memory was present in our cohort at the 2nd measurement in the group 3-6 months since infecting and nine months since infecting in 1st measurement.

Also, Hampshire et al. (2022) hypothesized that recovery of cognitive abilities would be slow at best, which is consistent with our result of the time aspect between measurements, where there was also deterioration between measurements**.** Also, the results of the multinomial logistic regression analysis, where there were differences between the 1st and 2nd measurements with deteriorating memory over time, support these findings. The effect of group belonging concerning time since infection with Covid-19 means that there are differences in remembering between groups and we agree with Hampshire et al., (2022) where they observed objective cognitive differences between those who had and never had COVID-19 infection.

Our findings are consistent with Colizzi et al. (2022) who found that the prevalence of cognitive and affective psychiatric signs such as memory deficits and anxiety-depressive symptoms increases over time, and symptoms and their consequences are fully manifested with a delay (Troyer et al. 2020) and we also agree with Berrenguera (2021) that symptoms are cyclical in nature, where some symptoms improve while others worsen. Damage to the integrity of the CNS naturally brings risks of various types of neuropsychological deficits. The most frequently described conditions correspond to mild cognitive impairment (Troyer et al. 2020).

These findings are based on the epidemiological situation in Slovakia and the measures that were in place at the time and had an impact on the later development of post-covid conditions, therefore may not be consistent with results in other countries where the epidemiological situation was different. However, more recent research in other countries suggests the same results mentioned above (Parotto et al., 2023). For this reason, we consider our findings relevant and consistent. Newer research suggests an effect of trauma that has an impact on long-term symptoms, they observed structural models that have an impact on post-Covid conditions (Panzeri et al., 2023).

We suggest exploring factors that could have mediating and moderating effects while exploring relationships because they could explain the variability of long-term symptoms. For the future search in Slovakia, we suggest exploring structural modeling as mentioned with a higher number of respondents with a multidisciplinar approach which could help increase the number of respondents and improve collaboration between experts as mentioned in Goodman et al., (2023). On the other hand, comparing the effects of factors between countries would also help to explain variability.

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