Brief Communication

Central Asian Journal of Medical Sciences
CAJMS

Cent Asian J Med Sci. 2026 Jun;12(2):69-78 https://doi.org/10.24079/CAJMS.2026.02.007

# Changes in mental health following COVID-19 infection: Results of a prospective cohort study in Mongolia

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**Submitted date:** Dec 15, 2025
**Accepted date:** Mar 30, 2026

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**Objective:** COVID-19 has been associated with persistent neuropsychiatric complications, yet prospective evidence from low- and middle-income countries remains limited. This study evaluated 12-month longitudinal changes in depression, anxiety, insomnia, and post-traumatic stress disorder (PTSD) among hospitalized patients with COVID-19 compared with non-COVID-19 controls in Mongolia. **Methods:** This prospective cohort study included 459 adults (326 COVID-19 cases and 133 controls) recruited from hospitals affiliated with the Mongolian National University of Medical Sciences between 2021 and 2023. Participants without baseline mental disorders were assessed at 7–14 days, 3 months, and 12 months using the PHQ-9, GAD-7, ISI, and PCL-5. Data were analyzed using $X^2$ tests, independent t-tests, and relative risk (RR) estimates, with statistical significance defined as $p < 0.05$. **Results:** The mean age of participants was 46.3 ± 13.8 years, and 58.4% were female. At 12 months, depression (37.3% vs. 16.9%; RR = 2.22, 95% CI: 1.28–3.83; p = 0.003) and anxiety (28.0% vs. 11.2%; RR = 2.49, 95% CI: 1.25–4.96; p = 0.006) remained significantly more common in the COVID-19 group than in controls. Insomnia decreased over time (33.3% vs. 49.4%; RR = 0.67; p = 0.037), whereas PTSD prevalence remained low in both groups (<3%, p > 0.05). Female participants and those aged 40–59 years showed a higher risk of adverse mental health outcomes. **Conclusions:** COVID-19 infection was associated with a significantly increased long-term risk of depression and anxiety up to 12 months after infection. These findings support routine mental health screening and sustained psychological follow-up as part of post-COVID care and provide evidence to inform long-term mental health policy in Mongolia.

**Keywords:** COVID-19; Depression; Anxiety; Insomnia; Post-traumatic stress disorder; Prospective cohort study

## Introduction

The novel coronavirus disease (COVID-19) was first reported in Wuhan, Hubei Province,

China, in December 2019, and the World Health Organization (WHO) subsequently declared it a global pandemic on March 11, 2020.[1] Since then, more than 770 million individuals have been infected and over 7 million deaths have been recorded across more than 230 countries, according to the WHO's 2024 report.[2] In Mongolia, the first confirmed case occurred on March 10, 2020, and by 2023 the Ministry of Health had documented more than 1 million infections and over 2,100 deaths.[3] Although initially characterized as a respiratory illness, COVID-19 has been shown to directly and indirectly affect the central nervous system, contributing to a wide range of psychological and psychiatric disorders.[4,5] Moreover, societal stressors associated with the pandemic including economic disruption, fear of infection, lockdown measures, social isolation, and information overload have further undermined population mental health.[6,7]

Previous research suggests that mental health burdens increased markedly during the early stages of the COVID-19 pandemic. The WHO's Mental Health Atlas (2022) reported that 25–35% of the global population experienced symptoms of depression or anxiety during the first year of COVID-19, with rates reaching up to 40% in regions such as Latin America, Southeast Asia, and Eastern Europe.[8,9] Ettman, et al. (2020), in a U.S. survey published in JAMA, found that depression prevalence tripled during the pandemic, with 27.8% of adults scoring ≥10 on the PHQ-9, consistent with clinically significant depressive symptoms.[10] Cohort studies have further shown that 30–60% of individuals infected with COVID-19 develop post-acute psychological symptoms, including anxiety, insomnia, memory impairment, and post-traumatic stress disorder (PTSD).[11-13] For example, Huang, et al. (2021) reported that among 1,733 Chinese patients assessed six months after infection, 23% experienced depression, 26% anxiety, and 30% insomnia.[11] Similarly, Xie et al. (2022), analyzing data from 150,000 U.S. participants, estimated post-COVID relative risks of 1.35 (95% CI: 1.30–1.40) for depression and 1.25 (95% CI: 1.20–1.31) for anxiety.[12]

The etiology of pandemic-related psychiatric disorders is multifactorial, involving both biological and psychological mechanisms.[13-15] SARS-CoV-2 is capable of entering the central nervous system via angiotensin-converting enzyme 2 (ACE2) receptors, leading to microglial activation, cytokine dysregulation, and alterations in serotonin metabolism.[14] Concurrently, fear of severe illness or death, social isolation, and economic instability generate psychoneuroimmunological stress responses that heighten vulnerability to depression and anxiety.[15]

Research on population mental health during the COVID-19 pandemic in Mongolia remains limited. A 2021 online survey conducted by the National Center for Mental Health reported that 28.7% of respondents exhibited moderate-to-severe depressive symptoms and 22.4% reported high levels of anxiety.[16] However, these findings were derived from cross-sectional data and therefore do not capture longitudinal changes following COVID-19 infection. Although international research on long COVID–related mental health sequelae is expanding, no systematic cohort studies have been undertaken in Mongolia.[17,18] Although strong family and community support structures characterize Mongolian society, limited access to mental health services and insufficient psychosocial education hinder the early detection and long-term monitoring of post-infection psychiatric disorders.[19]

This study aimed to assess 12-month longitudinal changes in depression, anxiety, insomnia, and PTSD among individuals with COVID-19, relative to a non-infected control group.

## Materials and Methods

We conducted a prospective cohort study from 2021 to 2023 at hospitals affiliated with the Mongolian National University of Medical Sciences (MNUMS), including the Mongolian–Japanese Hospital, the Central Hospital, and the National Center for Maternal and Child Health. A total of 552 hospitalized patients were enrolled and stratified into COVID-19 (case) and non–COVID-19 (control) groups based on RT-PCR test results. Participants were followed for 12 months, with assessments conducted at three intervals: short-term (14 days), medium-term (3 months), and long-term (12 months).

### Case and Control Definitions

- Cases (COVID-19 Group): Patients with RT-PCR–confirmed SARS-CoV-2 infection during hospitalization.
- Controls (non–COVID-19 Group): Patients hospitalized for other medical conditions who tested negative for COVID-19 throughout the study period.

### Inclusion Criteria

- Age ≥18 years;
- Currently hospitalized;

- Provided informed consent for voluntary participation;
- Were able to participate in follow-up assessments.

### Exclusion Criteria

- Presence of baseline mental disorders (PHQ-9 ≥10, GAD-7 ≥10, ISI ≥15, or PCL-5 ≥33);
- Pre-existing severe psychiatric conditions (e.g., schizophrenia, recurrent major depressive disorder, bipolar disorder);
- Current use of psychotropic medications or engagement in psychotherapy;
- Was unable to complete questionnaires.

Of the 552 initially enrolled participants, 93 were excluded due to baseline mental disorders, yielding a final sample of 459 individuals (326 COVID-19 cases and 133 controls).

### Assessment Tools

Participants were screened within the first 48 hours of hospitalization using validated psychological instruments:

1. PHQ-9 (Patient Health Questionnaire-9): A 9-item measure of depressive symptoms; scores ≥10 indicate clinical depression (Kroenke et al., 2001).
2. GAD-7 (Generalized Anxiety Disorder-7): A 7-item anxiety assessment; scores ≥10 indicate clinical anxiety (Spitzer et al., 2006).
3. ISI (Insomnia Severity Index): A 7-item scale assessing insomnia severity; scores ≥15 indicate moderate-to-severe insomnia (Morin et al., 2011).
4. PCL-5 (PTSD Checklist for DSM-5): A 20-item measure of PTSD symptoms; scores ≥33 indicate probable PTSD (Weathers et al., 2013).

Comorbidity of mental disorders were defined as meeting clinical thresholds on two or more scales. Data collection was conducted by trained mental health researchers.

### Follow-up Assessments

- 14 days: Telephone or in-person interviews following hospital discharge.
- 3 months: Online or in-person assessments (participation rate: 51.4%).
- 12 months: Final follow-up evaluation (participation rate: 35.7%).

### Statistical Analysis

We used IBM SPSS Statistics version 26.0 for data analysis. Descriptive statistics were presented as means and standard deviations (SD) for continuous variables and percentages for categorical variables. Group differences were examined using $X^2$ tests and independent t-tests. Primary outcomes prevalence of depression, anxiety, insomnia, and PTSD were reported as relative risks (RR) with 95% confidence intervals (CI). Statistical tests were employed to adjust for potential confounders, including age, sex, chronic medical conditions, and family status. The mean of three repeated measurements was compared between the two groups using a mixed-effects two-way ANOVA test with the Greenhouse–Geisser correction. For multiple comparisons within each group, the Tukey test was applied. The three repeated measurements were compared between the two groups, and the relative risk (RR) and 95% confidence intervals were estimated using a log-binomial regression model. Statistical significance was defined as p value less than $< 0.05$.

### Ethical Consideration

The ethical approval obtained from the MNUMS Ethics Committee (No. 2021/Z-08). All participants provided written informed consent after receiving full information regarding the study objectives, confidentiality, and the scope of data use. Personal identifiers were removed and replaced with unique IDs, with access restricted to authorized research personnel.

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### Data Quality and Reliability

Data collectors received standardized training prior to study implementation. Case report forms (CRFs) were double-entered, and incomplete or inconsistent entries were cross-checked against original sources. Baseline exclusion of individuals with pre-existing mental health symptoms ensured that only incident psychological disorders were captured. The prospective cohort design strengthened temporal sequencing and enhanced causal inference regarding the association between COVID-19 infection and subsequent psychiatric outcomes.

# Results

## Baseline Characteristics of Participants

A total of 459 participants were included in the analysis, comprising 326 individuals (71.0%) in the COVID-19 group and 133 individuals (29.0%) in the non–COVID-19 group. COVID-19 cases were generally younger, with a higher proportion under 40 years old, while controls were more often over 60 ($p<0.001$). Females were more common in the control group, whereas males predominated among cases ($p=0.003$). Marital status and education level did not differ significantly between groups. Employment status and type of employment showed significant differences: cases were more likely to be employed, working in government or private sectors, while controls included a higher proportion of retirees (both $p<0.001$). Household size and dwelling type also differed significantly, with cases more often living in larger households and in houses, whereas controls were more often in housing apartments (both $p<0.001$). Overall, several key demographic and socioeconomic variables differed between cases and controls, which may influence study outcomes (Table 1).

**Table 1.** Demographic information of participants.

| Characteristics | COVID-19 | Non-COVID-19 | Total | *p*-value |
|---|---|---|---|---|
| | n (%) | n (%) | n (%) | |
| **Age group** | | | | <0.001 |
| Under 39 | 201 (50.4) | 32 (20.9) | 233 (42.2) | |
| 40 - 49 | 86 (21.6) | 33 (21.6) | 119 (21.6) | |
| 50 - 59 | 67 (16.8) | 32 (20.9) | 99 (17.9) | |
| Over 60 | 45 (11.3) | 56 (36.6) | 101 (18.3) | |
| **Sex** | | | | 0.001 |
| Female | 225 (56.4) | 109 (71.2) | 334 (60.5) | |
| Male | 174 (43.6) | 44 (28.8) | 218 (39.5) | |
| **Marital status** | | | | 0.171 |
| Not married | 131 (32.8) | 41 (26.8) | 172 (31.2) | |
| Married | 268 (67.2) | 112 (73.2) | 380 (68.8) | |
| **Education** | | | | 0.405 |
| High | 190 (47.6) | 81 (52.9) | 271 (49.1) | |
| Specialized, secondary | 28 (7) | 11 (7.2) | 39 (7.1) | |
| High-school | 142 (35.6) | 43 (28.1) | 185 (33.5) | |
| Middle-school or low | 39 (9.8) | 18 (11.8) | 57 (10.3) | |
| **Employment status** | | | | <0.001 |
| No | 135 (33.8) | 79 (51.6) | 214 (38.8) | |
| Yes | 264 (66.2) | 74 (48.4) | 338 (61.2) | |
| **Employment status** | | | | <0.001 |
| Government agency | 81 (20.3) | 24 (15.7) | 105 (19) | |
| Private company | 110 (27.6) | 23 (15) | 133 (24.1) | |
| Self-employed | 74 (18.5) | 27 (17.6) | 101 (18.3) | |
| Other | 101 (25.3) | 70 (45.8) | 171 (31) | |
| Unemployed | 33 (8.3) | 9 (5.9) | 42 (7.6) | |
| **Family members** | | | | <0.001 |
| 1 - 2 | 74 (18.5) | 27 (17.6) | 101 (18.3) | |
| 3 -4 | 101 (25.3) | 70 (45.8) | 171 (31) | |
| More than 5 | 33 (8.3) | 9 (5.9) | 42 (7.6) | |
| **Dwelling type** | | | | <0.001 |
| Apartment | 243 (60.9) | 130 (85) | 373 (67.6) | |
| Other | 156 (39.1) | 23 (15) | 179 (32.4) | |
| **Total** | 399 (100) | 153 (100) | 552 (100) | |

*p value for Pearson's chi-squared test*

## Changes in Depression (PHQ-9 ≥ 10)

The proportion of individuals experiencing the outcome was higher in COVID-19 patients than in non-COVID-19 controls at all time points. While the difference at 14 days was not statistically significant (50% vs 40%, RR 1.24, p = 0.06), COVID-19 patients had a significantly higher risk at 3 months (44% vs 27%, RR 1.61, $p = 0.01$) and at 12 months (37% vs 17%, RR 2.22, $p = 0.003$). This indicates that COVID-19 is associated with a persistent, long-term increase in risk (Table 2).

**Table 2.** Changes in Depression Levels (PHQ-9 ≥ 10)

| Characteristics | COVID-19 | Non-COVID-19 | Total | RR [95% CI] | *p*-value | OR [95% CI] | *p*-value |
|---|---|---|---|---|---|---|---|
| | n (%) | n (%) | n (%) | | | | |
| **PHQ-9 ≥ 10 (14 days)** | | | | | | | |
| No | 164 (50.2) | 79 (59.8) | 243 (52.9) | ref | | ref | |
| Yes | 163 (49.8) | 53 (40.2) | 216 (47.1) | 1.241 [0.982 - 1.57] | 0.06 | 1.481 [0.983 - 2.232] | 0.06 |
| **PHQ-9 ≥ 10 (3 months)** | | | | | | | |
| No | 83 (56.5) | 65 (73) | 148 (62.7) | ref | | ref | |
| Yes | 64 (43.5) | 24 (27) | 88 (37.3) | 1.615 [1.095 - 2.381] | 0.011 | 2.088 [1.180 - 3.695] | 0.011 |
| **PHQ-9 ≥ 10 (12 months)** | | | | | | | |
| No | 47 (62.7) | 74 (83.1) | 121 (73.8) | ref | | ref | |
| Yes | 28 (37.3) | 15 (16.9) | 43 (26.2) | 2.215 [1.282 - 3.827] | 0.003 | 2.939 [1.422 - 6.074] | 0.004 |
| **GAD-7 ≥ 10 (14 days)** | | | | | | | |
| No | 199 (60.9) | 94 (71.2) | 293 (63.8) | ref | | ref | |
| Yes | 128 (39.1) | 38 (28.8) | 166 (36.2) | 1.36 [1.007 - 1.836] | 0.037 | 1.591 [1.027 - 2.464] | 0.037 |
| **GAD-7 ≥ 10 (3 months)** | | | | | | | |
| No | 103 (70.1) | 68 (76.4) | 171 (72.5) | ref | | ref | |
| Yes | 44 (29.9) | 21 (23.6) | 65 (27.5) | 1.269 [0.81 - 1.986] | 0.291 | 1.383 [0.757 - 2.529] | 0.292 |
| **GAD-7 ≥ 10 (12 months)** | | | | | | | |
| No | 54 (72) | 79 (88.8) | 133 (81.1) | ref | | ref | |
| Yes | 21 (28) | 10 (11.2) | 31 (18.9) | 2.492 [1.253 - 4.956] | 0.006 | 3.072 [1.341 - 7.037] | 0.008 |

*p value for Pearson's chi-squared test, RR - Relative risk, OR- Odds ratio, 95% CI - 95% confidence interval, ref - Reference category*

## Changes in Anxiety Levels (GAD-7 ≥ 10)

At 14 days, anxiety symptoms were more common in the COVID-19 group (39.1%) compared with controls (28.8%; RR = 1.36, $p = 0.037$). At 3 months, anxiety decreased to 29.9% in the COVID-19 group and 23.6% among controls ($p = 0.29$). At 12 months, anxiety stabilized at 28.0% in the COVID-19 group versus 11.2% in controls ($p = 0.006$; RR = 2.49, 95% CI: 1.25–4.96) (Table 3).

## Insomnia (ISI ≥ 15)

Insomnia was common in both COVID-19 and non–COVID-19 individuals at 14 days, with 40% of COVID-19 patients and 44% of controls experiencing moderate to severe symptoms. By 12 months, insomnia persisted in one-third of COVID-19 patients (33%) but remained higher in non-COVID individuals (49%), resulting in a lower relative risk for COVID-19 patients (RR=0.67) (Table 3).

## Post-traumatic Stress Disorder (PTSD; PCL-5 ≥ 33)

PTSD symptoms were rare in both groups, affecting only 3% of COVID-19 patients and 2% of non-COVID participants at 14 days, and virtually disappearing in COVID-19 patients by 12 months, with minimal prevalence in controls (1%). Overall, COVID-19 did not appear to increase the long-term risk of insomnia or PTSD (Table 3).

**Table 3.** Summary of Key Outcomes

| Characteristics | COVID-19 | Non-COVID-19 | Total | RR [95% CI] | *p*-value | OR [95% CI] | *p*-value |
|---|---|---|---|---|---|---|---|
| | n (%) | n (%) | n (%) | | | | |
| **ISI ≥ 15 (14 days)** | | | | | | | |
| No | 269 (58.6) | 195 (59.6) | 74 (56.1) | ref | | ref | |
| Yes | 190 (41.4) | 132 (40.4) | 58 (43.9) | 0.919 [0.727 - 1.16] | 0.482 | 0.864 [0.574 - 1.300] | 0.482 |
| **ISI ≥ 15 (3 months)** | | | | | | | |
| No | 139 (58.9) | 91 (61.9) | 48 (53.9) | ref | | ref | |
| Yes | 97 (41.1) | 56 (38.1) | 41 (46.1) | 0.827 [0.61 - 1.122] | 0.228 | 0.720 [0.423 - 1.228] | 0.228 |
| **ISI ≥ 15 (12 months)** | | | | | | | |
| No | 95 (57.9) | 50 (66.7) | 45 (50.6) | ref | | ref | |
| Yes | 69 (42.1) | 25 (33.3) | 44 (49.4) | 0.674 [0.46 - 0.989] | 0.037 | 0.511 [0.271 - 0.965] | 0.038 |
| **PCL-5 ≥ 33 (14 days)** | | | | | | | |
| No | 446 (97.2) | 317 (96.9) | 129 (97.7) | ref | | ref | |
| Yes | 13 (2.8) | 10 (3.1) | 3 (2.3) | 1.346 [0.376 - 4.812] | 0.646 | 1.356 [0.367 - 5.009] | 0.647 |
| **PCL-5 ≥ 33 (3 months)** | | | | | | | |
| No | 233 (98.7) | 145 (98.6) | 88 (98.9) | ref | | ref | |
| Yes | 3 (1.3) | 2 (1.4) | 1 (1.1) | 1.211 [0.111 - 13.162] | 0.875 | 1.214 [0.108 - 13.582] | 0.875 |
| **PCL-5 ≥ 33 (12 months)** | | | | | 0.357 | | 0.997 |
| No | 163 (99.4) | 75 (100) | 88 (98.9) | | | | |
| Yes | 1 (0.6) | 0 (0) | 1 (1.1) | | | | |

*p value for Pearson's chi-squared test, RR - Relative risk, OR- Odds ratio, 95% CI - 95% confidence interval, ref - Reference category*

## Comparison of Mean Scores of PHQ, GAD, Insomnia and PTSD

Longitudinal analysis of mental health outcomes among hospitalized patients revealed significant improvements over time across both control and COVID-19 (case) groups. PHQ (depression) and GAD (anxiety) scores decreased from 14 days to 12 months in both groups (PHQ: controls 5.09➔2.95, cases 6.81➔4.28; GAD: controls 3.86➔2.44, cases 5.89➔4.06), with significant within-subject effects ($P < 0.001$) but non-significant group × time interactions (PHQ $P = 0.085$, GAD $P = 0.418$), indicating similar trajectories. Insomnia and PTSD scores also declined over time; however, significant interactions were observed (insomnia $P = 0.001$, PTSD $P = 0.003$), suggesting that the temporal patterns differed between COVID-19 and control patients (Figure 1). These results indicate that while mental health symptoms generally improved in all participants, COVID-19 status influenced the rate or pattern of recovery for insomnia and PTSD (Table 4).

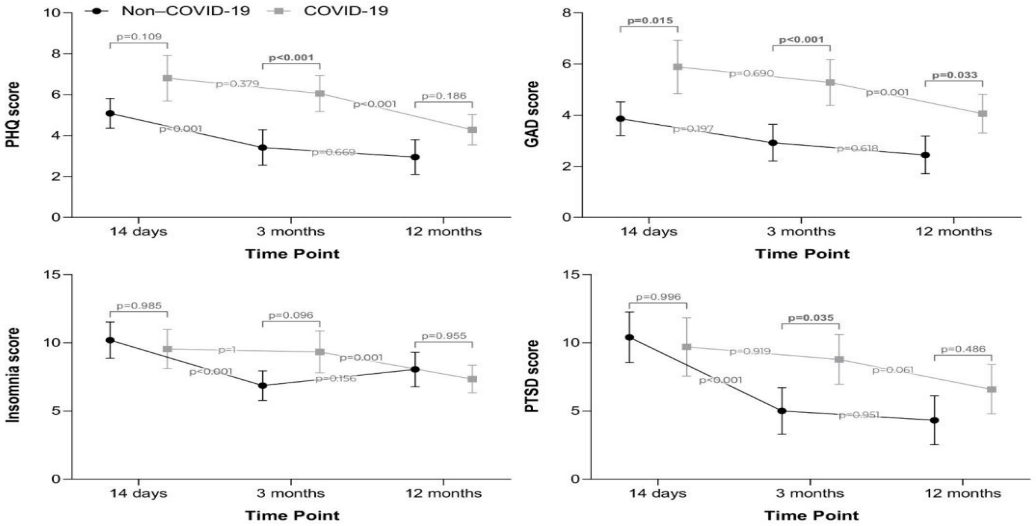


Figure 1. Comparison of mean scores of PHQ, GAD, insomnia and PTSD

**Table 4.** Comparison of mean scores of PHQ, GAD, Insomnia and PTSD

| Timepoint | PHQ Score | | *p* value |
|---|---|---|---|
| | COVID-19 Group (mean ± s.d) | non-COVID-19 Group (mean ± s.d) | |
| **Overall Two-way Mixed ANOVA Test** | | | 0.085 |
| 14 Days | 6.81 ± 5.52 | 5.09 ± 3.68 | Tukey (vs): 0.109 |
| 3 Months | 6.06 ± 4.34 | 3.41 ± 4.32 | Tukey (vs): <0.001 |
| 12 Months | 4.28 ± 3.67 | 2.95 ± 4.27 | Tukey (vs): 0.186 |
| Within-Group Pairwise (14 Days vs. 3 Months) | 0.379 | <0.001 | |
| Within-Group Pairwise (3 Months vs. 12 Months) | <0.001 | 0.699 | |
| **Timepoint** | **GAD Score** | | ***p* value** |
| | **COVID-19 Group (mean ± s.d)** | **non-COVID-19 Group (mean ± s.d)** | |
| **Overall Two-way Mixed ANOVA Test** | | | 0.418 |
| 14 Days | 5.89 ± 5.14 | 3.86 ± 3.29 | Tukey (vs): 0.015 |
| 3 Months | 5.28 ± 4.44 | 2.92 ± 3.61 | Tukey (vs): <0.001 |
| 12 Months | 4.06 ± 3.75 | 2.44 ± 3.70 | Tukey (vs): 0.033 |
| Within-Group Pairwise (14 Days vs. 3 Months) | 0.690 | 0.197 | |
| Within-Group Pairwise (3 Months vs. 12 Months) | 0.001 | 0.618 | |
| **Timepoint** | **Insomnia Score** | | ***p* value** |
| | **COVID-19 Group (mean ± s.d)** | **non-COVID-19 Group (mean ± s.d)** | |
| **Overall Two-way Mixed ANOVA Test** | | | 0.001 |
| 14 Days | 9.54 ± 7.13 | 10.20 ± 6.67 | Tukey (vs): 0.985 |
| 3 Months | 9.33 ± 7.59 | 6.86 ± 5.44 | Tukey (vs): 0.096 |
| 12 Months | 7.34 ± 5.02 | 8.05 ± 6.34 | Tukey (vs): 0.955 |
| Within-Group Pairwise (14 Days vs. 3 Months) | 1.000 | <0.001 | |
| Within-Group Pairwise (3 Months vs. 12 Months) | 0.001 | 0.156 | |
| **Timepoint** | **PTSD Score** | | ***p* value** |
| | **COVID-19 Group (mean ± s.d)** | **non-COVID-19 Group (mean ± s.d)** | |
| **Overall Two-way Mixed ANOVA Test** | | | 0.003 |
| 14 Days | 9.70 ± 10.55 | 10.40 ± 9.29 | Tukey (vs): 0.996 |
| 3 Months | 8.78 ± 9.01 | 5.00 ± 8.57 | Tukey (vs): 0.035 |
| 12 Months | 6.59 ± 8.89 | 4.32 ± 8.99 | Tukey (vs): 0.486 |
| Within-Group Pairwise (14 Days vs. 3 Months) | 0.919 | <0.001 | |
| Within-Group Pairwise (3 Months vs. 12 Months) | 0.061 | 0.951 | |

*s.d -Standard Deviation; PHQ - Patient Health Questionnaire; GAD - Generalized Anxiety Disorder; PTSD - Post-Traumatic Stress Disorder.*
*Overall ANOVA P-value is derived from a two-way mixed ANOVA main/interaction effect model.*
*Tukey (vs) denotes cross-sectional between-group post-hoc pairwise comparisons at that specific timepoint (COVID-19 vs non-COVID-19).*
*Within-Group Pairwise values denote longitudinal post-hoc changes within the respective cohort.*

## Trend Analysis

Depression and anxiety peaked at approximately 45–50% at 14 days in the COVID-19 group and subsequently declined at 3 and 12 months, whereas symptom rates in the control group remained relatively stable at 20–30% throughout the study period. Over the 12-month follow-up, depression decreased by roughly 25%, anxiety by about 11%, and insomnia by approximately 10% among COVID-19 participants. Despite these improvements, one in three individuals in the COVID-19 group continued to exhibit at least one psychological symptom at the one-year follow-up.

## Subgroup analyses

Age: Participants aged 40–59 years exhibited a higher prevalence of depression at 12 months (45.6%; $p = 0.021$), while those aged ≥60 years showed elevated anxiety levels (31.8%; $p = 0.034$).

Sex: Female participants demonstrated higher rates of depression compared with males (42.2% vs. 30.4%; $p = 0.04$), and insomnia was also more common among females (36.8% vs. 28.1%).

Chronic conditions: Individuals with chronic comorbidities had a 1.8-fold increased risk of anxiety and a 1.5-fold increased risk of insomnia ($p < 0.05$).

At 12 months, depression and anxiety remained significantly more prevalent in the COVID-19 group compared with the control group. Insomnia did not decline overall and showed an increase among non–COVID-19 participants, potentially indicating persistent sleep disturbances unrelated to infection. PTSD prevalence remained consistently low (<3%) across all time points. Overall, these findings indicate the presence of subclinical psychiatric sequelae that persist from 3 to 12 months following COVID-19 infection.

# Discussion

This prospective cohort study demonstrates that COVID-19 infection is associated with significantly higher levels of depression and anxiety compared with non-infected controls, persisting up to 12 months post-infection. In the COVID-19 group, depression prevalence declined from 49.8% at 14 days to 37.3% at 12 months but remained more than twice as high as in controls (16.9%), providing evidence of post-COVID mental health sequelae.[11,15,21] These findings are consistent with international studies: Huang, et al. (Lancet Psychiatry, 2021) reported 23% depression and 26% anxiety at six months,[11] while Taquet, et al. (Lancet Psychiatry, 2021) observed 32.8% depression at one year, comparable to our 37.3%.[13] U.S. data indicate that 27.8% of adults scored ≥10 on the PHQ-9.[10]

The 12-month anxiety prevalence of 28.0% in the COVID-19 group approximately 2.5 times higher than controls may be attributable to post-infection inflammatory responses, cytokine activation, and dysregulation of serotonin pathways, as described by Dantzer et al. (Nat Rev Neurosci, 2018).[14] Additional psychosocial factors, including social isolation, media exposure, and economic uncertainty, likely contribute to sustained mental health instability.[15,22]

### Insomnia and Adaptation

Insomnia in the COVID-19 group declined from 40.4% to 33.3% over 12 months, remaining lower than in controls, suggesting physiological and psychological adaptation.[11,13,23] In contrast, the increase in insomnia among controls may reflect broader pandemic-related stressors or chronic organic sleep disturbances.[15,24]

### PTSD Levels

PTSD prevalence remained low (<3%) throughout the study, contrasting with higher global estimates (e.g., 18% reported by Taquet et al.).[13] The relatively low rates in Mongolia may be influenced by strong family cohesion, communal support, and cultural resilience, which facilitate post-stress adaptation.[19,25,27]

### Sex, Age, and Co-morbidity

Higher rates of depression and insomnia among females are consistent with global trends and may be related to hormonal fluctuations, family caregiving roles, and limited access to psychosocial support.[5,13,20,21] Middle-aged adults (40–59 years) showed higher depression, whereas older adults exhibited elevated anxiety, reflecting the combined effects of occupational stress and age-related health vulnerabilities.[15,22]

### Strengths and Limitations

This study presents first 12-month prospective cohort comparing COVID-19 and non-COVID-19 patients, providing novel longitudinal data on post-infection mental health outcomes in Mongolia. Our limitations may include hospital-based, which may limit to represent general population; reliance on self-report; not fully adjustment for socioeconomic factors; and potential underrepresentation of mild or asymptomatic cases.

### Future Directions

Future research should include larger population-based cohorts and longer follow-up periods to better understand the long-term trajectory of post-COVID mental health outcomes. Studies incorporating biological markers, socioeconomic variables, and psychosocial factors are needed to clarify the mechanisms

underlying persistent depression and anxiety after infection. In addition, intervention studies should evaluate effective strategies for prevention and management of post-COVID mental health sequelae.

## Conclusion

At 12 months post-infection, depression among individuals with COVID-19 was 2.2 times higher and anxiety was 2.5 times higher than in non-infected controls. In contrast, the prevalence of long-term insomnia was 0.67 times lower in the COVID-19 group, suggesting a possible physiological and psychological adaptation over time. PTSD prevalence remained consistently low (below 3 percent) across all follow-up periods. Overall, COVID-19 infection appears to be an independent long-term risk factor for psychiatric disorders.

## Conflict of Interest

The authors declare no conflict of interest.

## Acknowledgements

We sincerely thank the administrations of the Mongolia–Japan Teaching Hospital, MNUMS Central Hospital, and the National Center for Maternal and Child Health; the leadership of the MNUMS School of Medicine; all participants who volunteered for this study; and our research team for their invaluable contributions.

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