Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Psychiatry Research 305 (2021) 114243

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Long term impact of Covid-19 infection on sleep and mental health: A cross-sectional study

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ARTICLE INFO

Keywords:
COVID-19
Depression
Anxiety
Insomnia
Mental health

ABSTRACT

The long-term impact of the COVID-19 infection on mental health in people and its relation to the severity is unclear. We aimed to study the long-term effect of post-COVID-19 disease on sleep and mental health and to detect possible relationship between severity of COVID-19 at onset and sleep and mental illness. We enrolled 182 participants 6 months post COVID-19 infection and grouped into non-severe(101),severe(60) and critical(20) according to according to WHO guidance. All participants were assessed using Pittsburgh Sleep Quality Index ", Post traumatic stress disorder (PTSD) Checklist for DSM-5, and Symptom Checklist90 test. Only 8.8% had no psychiatric symptoms while 91.2% had psychiatric symptoms as follow (poor sleep (64.8%), PTSD (28.6%), somatization (41.8%), obsessive-compulsive (OCD) (19.8%), depression (11.5%), anxiety (28%), phobic-anxiety (24.2%), psychoticism (17.6%)). Diabetes, oxygen support or mechanically ventilated were a risk for sleep impairment, while high Neutrophil/lymphocyte ratio**(NLR)** was the only risk factor for PTSD. Other psychiatric illnesses had several risk factors: being female, diabetes, oxygen support or mechanically ventilated. Abnormal sleep, somatization and anxiety are the most common mental illnesses in Post-Covid19. The critical group is common associated with PTSD, anxiety, and psychosis. Being female, diabetic, having oxygen support or mechanically ventilated, and high NLR level are more vulnerable for mental illness in post COVID19.

1. Introduction

Covid-19 was the first pandemic infectious disease in the 21st century (Xie et al., 2020). The virus spreads rapidly worldwide by travellers, with more than 72 million cases and more than 1 million deaths world-wide by December 14, 2020(Worldometer COVID-19 Coronavirus Pandemic, 2020).

However, the impact of COVID-19 on mental health have been raised since its early stages (Gellan et al., 2021; Xiang et al., 2020). After some pandemics, psychological consequences have been reported as following severe acute respiratory syndrome (SARS), Ebola, and H1N1(Li and Wang, 2020; Pan et al., 2020; Taquet et al., 2021; Xiang et al., 2020). A meta-analysis estimated the incidence of psychiatric disorders after SARS and Middle East respiratory syndrome outbreaks suggested that coronavirus infections can lead to delirium, anxiety, depression, manic symptoms, poor memory, and insomnia (Rogers et al., 2020)

Various psychological diseases have been predicted to occur in COVID-19 survivors, as they faced significant challenges to survive fear from infecting other members, probability of death at any time, and fear from future repeated infection in addition to physical stress from the disease itself. There are biological factors of mental disorders related to COVID-19 infection that could also be implicated as the inflammation process involved in many psychiatric disorders (Wang et al., 2021).

A questionable point in the relation between COVID-19 infection and psychological disorders is whether SARS-Co 19 infection increases liability to psychological disorders, or the reverse theory is more accepted. Recent metanalysis study found that there was increased risk of depression and anxiety in COVID-19 patients compared to other inpatients. This study also recommended further assessment of the long-term mental health effect of COVID-19 infections (Deng et al., 2021). In addition, a previous large study evaluated psychological disorders within 3 months after diagnosis of COVID-19 infection. It found that the COVID-19 survivors had a significantly higher rate of psychiatric

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https://doi.org/10.1016/j.psychres.2021.114243
Received 7 May 2021; Received in revised form 3 October 2021; Accepted 10 October 2021
Available online 12 October 2021

Abbreviation

SCL 90	symptom Checklist 90
PCL-5	post-traumatic stress disorder (PTSD)
PSQI	Pittsburgh Sleep Quality Index
TLC	Complete blood count; total leucocyte count
RBC	red blood cells
HB	haemoglobin level
ALC	absolute lymphocyte count
AMC	absolute monocyte count
ANC	absolute neutrophil count
NLR	Neutrophil/lymphocyte ratio
CRP	(C-reactive protein)
MSCT	Multi-slice computed tomography

disorders, dementia, and insomnia; moreover, a previous psychiatric illness was independently associated with an increased risk of being diagnosed with COVID-19 (Taquet et al., 2021).

In current study, we aimed to evaluate the long-term impact of COVID-19 and its risk factors on sleep, and mental health, and to detect the relationship between mental disorders and COVID −19 severity after six months of infection.

2. Methods

2.1. Participants

A cross-sectional study enrolled 300 participants who admitted at Assiut university hospital after their diagnosed with Covid-19 from 1st of July to 1st of September 2020 by using real-time PCR methods in throat swab specimens (World Health Organization, 2020). All patients were asked to come to the outpatient clinics of Assiut University hospital, six months after the discharge for follow up. Follow up of those patients started from 1st of January 2021 and ended at 1st of Mach, 2021. Out of 300 patients, only 182 patients were eligible according to inclusion and exclusion criteria as follow: age 18 years old or above who had documented diagnosis of Covid-19 according to WHO guidance. Patients with a history of psychiatric disorders before diagnosis with COVID-19 were excluded.

Eligible participants were classified into 3 groups at the time of diagnosis according to criteria reported by (Wu et al., 2020):

(1) Critical (A): including those with respiratory failure that requires artificial ventilation, shock, or any end-organ damage.
(2) Severe (B): including those with a ratio of arterial partial oxygen pressure to inspired oxygen fraction (PaO_2/FiO_2) <300 mmHg, respiratory rate >30 breaths per minute, lung infiltrates >50% or patients with SpO2 <94% in room air.
(3) Non-severe (C): all remaining patients who did not meet the criteria for groups A and B.

The critical group: included 20 patients (8 females and 12 males) with mean age was 59±11.462. The severe group: included 60 patients (24 females and 37 males) with mean age was 54.98±15.05. The non-severe group: included 101 patients (52 females and 49 males) with mean age was 38.88±16.07.

2.2. Ethical consideration

The Faculty of Medicine's institutional review board, Assiut University, granted ethical approval for the study and registered it as a clinical trial. All participants had written informed consent to take part in the research. They were assured of data protection and were informed that data in anonymized form would be available. This study was carried out following the latest version of the Declaration of Helsinki.

2.3. Procedure

2.3.1. Data on hospital admission

Each patient was subjected to the following sociodemographic and clinical data. It included: age, sex, marital status, educational level, history of smoking, diabetes mellitus (DM), hypertension (HTN), and cardiovascular disease (CVD), the severity of COVID 19, duration of hospital admission, oxygen supply, and need for mechanical ventilation.

Laboratory data. Complete blood count; total leucocyte count (TLC), red blood cells (RBC), haemoglobin level (HB), absolute lymphocyte count (ALC), absolute monocyte count (AMC), absolute neutrophil count (ANC), Neutrophil/lymphocyte ratio (NLR =ANC/ALC). CRP (C-reactive protein), serum ferritin, and D-dimer. All collected laboratory results are at the time of diagnosis.

Imaging data. Multi-slice computed tomography (MSCT) of the chest of the patients, which was classified into either specific finding suggestive to COVID-19 infection present or not as bilateral or unilateral multifocal ground-glass opacities that classically predominate in the peripheral, posterior, and basal part of the lungs or other less specific findings.

2.3.2. During follow up visit (six month after COVID-19 infection) each patient patients were subjected to a full psychiatric and medical assessment at the beginning of the study then had the following

Pittsburgh sleep quality index "PSQI"(Buysse et al., 1989). It is used to detect sleep disturbance or deficits. The PSQI has a scoring key that can be used to calculate a patient's seven subscores, which range from 0 to 3. The subscores are added together to produce a "global" score that ranges from 0 to 21. A global score of 5 or higher denotes poor sleep quality, the higher the score, the worse the sleep quality. Each question assesses a different aspect of sleep problems.

Post traumatic disorder checklist for DSM-5 (PCL-5): (Weathers et al., 2013): "PCL-5". It is a 20 item self-report and measures the symptoms of post-traumatic stress disorder (PTSD) by using criteria of Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition (DSM-5). The cut off used for the PCL5 is 33 or higher to efficient for diagnosing PTSD (Bovin et al., 2016).

Symptom checklist 90 "SCL 90"(Derogatis, 1983). It is a 90-item questionnaire used to assess psychological problems. Each item is scored on a scale from 0 to 4 based on how much an individual was bothered by each item. It has 9 subscales: (Somatization, Obsessive-compulsive, Interpersonal sensibility, Depression, Anxiety, Anger-hostility, Phobic-anxiety, Paranoid ideation, Psychoticism).

2.4. Statistical analysis

SPSS was used to conduct the analysis (version 26 IBM, Armonk, NY, USA). The mean and standard deviation of continuous data were measured, and the frequency of nominal data was measured (percent). The three study groups' nominal data were compared using the chi-square test, while the three groups' mean was compared using the ANOVA. Multivariate logistic regression was done to identified risk factors for PCL-5, PSQI, and 7 major psychiatric disorders regarding SCL90. $P<0.05$ was considered statistically significant.

3. Results

3.1. Baseline assessment

3.1.1. Sociodemographic and clinical data

The mean age of was significantly higher in the critical group and the severe group than the non-severe group (59±11.462, 54.98±15.05, 38.88±16.07, respectively) ($P < 0.0001$).

Duration of admission was significantly longer (more than 12 days) in the critical (65%) and severe groups (62.3%) in comparison to the non-severe group (30.7%). Hypertension (35%) and cardiovascular disease (15%) were significantly more in the critical group ($P = 0.0001$). On the other side diabetes (32.8) was more in the severe group ($P = 0.0001$). Details illustrated in Table 1.

3.1.2. Laboratory and imaging finding

The laboratory examination showed that the mean haemoglobin level was significantly higher in the non-severe group (12.86±2.16) then the severe group (11.67±2.58) then the critical group (11.26±2.38) ($P = 0.001$). White blood cell indices, namely TLC (10.25±3.57 vs. 7.83±5.86 vs. 5.41±2.78; $P<0.0001$), ANC (8.04±3.39 vs. 5.05± 5.22 vs. 2.89 ± 2.17; $P < 0.0001$) and NLR (5.26±2.76 vs. 3.45±3.73 vs. 1.71±1.13; $P<0.0001$) were significantly higher in a critical group vs. severe vs. non-severe group, respectively.

Regarding the inflammatory markers, ferritin and D-dimer were significantly higher in the critical compared to the severe and non-severe patients ($P = 0.002$, $P < 0.0001$, respectively). About 70% of severe patients required oxygen aid ($P < 0.0001$), while 40% of the critical group required mechanical ventilation ($P < 0.0001$).

3.2. Sleep disturbance and mental illness six-month post COVID-19 infection

Out of 182 only 16 participants (8.8%) did not have any sleep or psychiatric problem. About 118 participants (64.8%) had poor sleep quality, while 52 participants (28.6%) had Probable PTSD response. The highest percentage of symptomatology was somatization (41.8%), followed by anxiety (28%), anger-hostility, phobic-anxiety (24.2%), obsessive-compulsive was (19.8%), interpersonal sensibility was (0.5%), depression was (11.5%), anger-hostility was (15.9%), paranoid ideation was (10.4%), and psychoticism was (17.6%).

3.2.1. Relation between the severity of COVID-19 infection at base line and sleep disturbance and mental illness

In Table 2, there was no statistically significant difference among the studied groups regarding sleep quality measured by PSQI, post-traumatic stress disorder measured by PCL-5, and somatization and obsessive-compulsive subscales measured by SCL90. Poor quality of sleep formed the most significant proportion among all studied groups while the higher percentages of the probable PTSD response were in the critical group (45%).

In comparison within each group, the non-severe group and severe group, the low percentages of abnormal response were observed in all subscales of SCL90 except somatization relative to borderline or normal responses. While the critical group showed abnormal response represented the highest proportion of anxiety (40%) relative to borderline or normal responses.

3.3. Identification of possible risk factors of mental illness in post COVID-19 patients

Multiple risk factors that affected sleep quality and PTSD were studied in multivariate regression analysis were shown in Table 3. Levels of education [elementary school ($P = 0.013$), and high school ($P = 0.013$)] were less vulnerable for sleep quality disorders while being just read and write ($P = 0.001$), diabetes ($P = 0.035$), severe group ($P =$

Table 1
Baseline characteristic of COVID-19 cases.

	Total of cases($N = 182$)	Non-severe group($N = 101$)	Severe group ($N = 61$)	Critical group($N = 20$)	*P*-value
Age in Years (mean ±SD)	46.49 ± 17.4	38.88 ± 16.07	54.98 ± 15.05	59 ± 11.462	**<0.0001**
Gender					
Male	84 (46.2%)	49 (48.5%)	37 (60.7%)	12 (60%)	0.273
Female	98 (53.8%)	52 (51.5%)	24 (39.3%)	8 (40%)	
Marital status					
Single	36 (19.8%)	22 (21.8%)	12 (19.7%)	2 (10%)	**0.038**
Married	128 (70.3%)	64 (63.4%)	48 (78.7%)	16 (80%)	
Divorce	10 (5.5%)	10 (9.9%)	0(0%)	0 (0%)	
Widow	8 (4.4%)	5 (5%)	1 (1.6%)	2 (10%)	
Education					
Reading and writing	28 (15.4%)	17 (16.8%)	8 (13.1%)	3 (15%)	0.503
Elementary school	12 (6.6%)	8 (7.9%)	3 (4.9%)	1 (5%)	
High school	16 (8.8%)	12 (11.9%)	4 (6.6%)	0 (0%)	
Higher education	126 (69.2%)	64 (63.4%)	46 (75.4%)	16 (80%)	
Smoking					
smoker	56 (30.8%)	37 (36.6%)	13 (21.3%)	6 (30%)	**<0.0001**
Non-smoker	126 (69.2%)	64 (63.4%)	48 (78.7%)	14 (60%)	
Duration of admission	12.24 ± 1.9	11.89 ± 1.44	12.25 ± 1.82	14 ± 3	**<0.0001**
More than 12 days	82 (45.1%)	31 (30.7%)	38 (62.3%)	13 (65%)	0.025
Less than 12 days	100 (54.9%)	70 (69.3%)	23 (37.7%)	7 (35%)	
Comorbidities					
DM	28 (15.4%)	4 (4%)	20 (32.8%)	4 (20%)	**<0.0001**
HTN	16 (8.8%)	3 (3%)	6 (9.9%)	7 (35%)	**<0.0001**
CVD	8 (4.4%)	3 (3%)	2 (3.3%)	3 (15%)	**<0.0001**
Laboratory (CBC)					
HB (g/dL)	12.29 ± 2.41	12.86 ± 2.16	11.67 ± 2.58	11.26 ± 2.38	**0.001**
Platelets ($\times 10^9$/L)	228.84 ± 92.62	232.42 ± 92.05	215.06 ± 80.74	252.85 ± 123.5	0.242
TLC ($\times 10^9$/L)	6.75 ± 4.4	5.41 ± 2.78	7.83 ± 5.86	10.25 ± 3.57	**<0.0001**
ANC ($\times 10^9$/L)	4.17 ± 3.94	2.89 ± 2.17	5.05 ± 5.22	8.04 ± 3.39	**<0.0001**
ALC ($\times 10^9$/L)	1.81 ± 1.02	1.79 ± 0.73	1.93 ± 1.46	1.61 ± 0.43	0.444
AMC ($\times 10^9$/L)	0.78 ± 1.88	0.94 ± 2.5	0.57 ± 0.35	0.58 ± 0.23	0.424
NLR	2.68 ± 2.75	1.71 ± 1.13	3.45 ± 3.73	5.26 ± 2.76	**<0.0001**
Inflammatory markers					
CRP (mg/l)	52.07 ± 103.91	46.803 ± 127.74	49.68 ± 53.44	86.03 ± 81.04	0.298
Ferritin (mcg/ml)	368.76 ± 449.53	266.28 ± 349.39	496.06 ± 473.86	498.03 ± 669.35	**0.002**
D- dimer (mcg/ml)	1.53 ± 1.54	0.64 ± 0.52	2.24 ± 0.8	3.88 ± 2.75	**<0.0001**
MSCT chest					
No affection	10 (5.5%)	9(8.9%)	0(0%)	1(5%)	0.054
affection	172 (94.5%)	92 (91.1%)	61 (100%)	19(95%)	

(continued on next page)

Table 1 (*continued*)

	Total of cases(*N* = 182)	Non-severe group(*N* = 101)	Severe group (*N* = 61)	Critical group(*N* = 20)	*P*-value
Oxygen support					
Any oxygen aids other than mechanical ventilation n (%)	68 (37.4%)	12 (11.9%)	43 (70.5%)	13 (65%)	**<0.0001**
Mechanical ventilation n (%)	8 (4.4%)	0 (0%)	0 (0%)	8 (40%)	**<0.0001**

ALC: Absolute Lymphocytic Count, **AMC:** Absolute Monocyte Count, **ANC:** Absolute neutrophilic count, **CBC:** Complete Blood Count, **CRP:** C reactive protein, **CVD:** Cerebro-Vascular disease, **DM:** Diabetes, **HB:** Hemoglobin, **HTN:** Hypertension, **MSCT**: Multi-Slice Computerized Tomography, **NLR**: Neutrophil Lymphocyte Ratio, **TLC:** Total Leucocyte Count.
Chi test and ANOVA test used for statistical Analysis (significant *P* value <0.05).

0.001), and use of oxygen aids ($P = 0.001$) were independent risk factors for sleep quality impairment. In contrast, just read and write ($P = 0.017$) and have high NLR ($P = 0.031$) were a significant risk for PTSD.

In Table 4, The multivariate logistic regression module shown risk factors on somatization, anxiety, depression, and obsessive-compulsive disorder of the studied group. Surprisingly, none of the studied risk factors were associated with somatization disorder. Adults less than 60 years were less vulnerable for anxiety while being female ($P = 0.004$) and had non-severe presentations were independent risk factors for anxiety.

Patients with age range from18 to 30years ($P = 0.005$) were less risky for depression while being diabetic ($P = 0.039$) and had low Hb levels ($P = 0.008$) were more vulnerable for depression.

Regarding obsession, adults less than 60 years were decreased risk of disorder but being smokers was increased risk for that disorder ($P = 0.028$).

On the other hand, females, patients who were on oxygen support, were mechanically ventilated, just read and write ($P = 0.03$), diabetics, non-severe, and severe groups of patients were at higher risk of phobic-anxiety disorder; while adults less than 60 years were at lower risk of phobic anxiety. According to paranoid ideation, females ($P = 0.023$), being just read and write ($P = 0.01$), had non-severe ($P = 0.003$) or severe groups ($P = 0.009$) were more likely to develop. However, adults less than 60 years, single or married patients had reduced risk for paranoid ideation. In contrast, females, diabetics, and just read and write were independent predictors for psychosis; detailed analysis is shown in Table 5.

4. Discussion

In relation to the COVID-19 pandemic, many studies investigated its psychological impact on the general population (Li and Wang, 2020), newly recovered patients (Pan et al., 2020), and within 3 months post COVID-19 diagnosis (Taquet et al., 2021). Previous research found that psychiatric morbidities can persist for over 2 years in patients previously infected by SARS (Mak et al., 2009). So, to the best of our knowledge, this study is the first study that addressed the long-term impact of COVID-19 infection and its risk factors on sleep and mental health and their relation to severity, comorbidities, and other risk factors.

In current study, we reported that only 8.8% of participants had no sleep disturbance or psychiatric symptoms, while 91.2% had psychiatric symptoms as follow: poor sleep (64.8%), PTSD (28.6%), somatization (41.8%), obsessive-compulsive (19.8%), depression (11.5%), anxiety (28%), phobic-anxiety (24.2%), psychoticism (17.6%).

During surge of COVID-19 pandemic, an Egyptian study conducted on general population and health care workers reported that incidence

Table 2
Mental health illness in the studied population 6 months after recovery.

	Total of cases (*N* = 182)	Non-severe group (*N* = 101)	Severe group (*N* = 61)	Critical group (*N* = 20)	*P*-value
PSQI					
Good quality of sleep	64 (35.2%)	36 (35.6%)	21 (34.4%)	7 (35%)	0.988
Poor quality of sleep	118 (64.8%)	65 (64.4%)	40 (65.6%)	13 (65%)	
PCL-5					
No PTSD	130 (71.4%)	75 (74.3%)	44 (72.1%)	11 (55%)	0.217
Probable PTSD	52 (28.6%)	26 (25.7%)	17 (27.9%)	9 (45%)	
Somatization					
Normal	52 (28.6%)	29 (28.7%)	16 (26.2%)	7 (35%)	0.026
Borderline	54 (29.7%)	25 (24.8%)	18 (29.5%)	11 (55%)	
Abnormal	76 (41.8%)	47 (46.5%)	27 (44.3%)	2 (10%)	
Obsessive-compulsive					
Normal	94 (51.6%)	53 (52.5%)	31 (50.8%)	10 (50%)	0.0001
Borderline	52 (28.6%)	17 (16.8%)	26 (42.6%)	9 (45%)	
Abnormal	36 (19.8%)	31 (30.7%)	4 (6.6%)	1(5%)	
Interpersonal sensibility					
Normal	142 (78%)	72 (71.3%)	54 (88.5%)	16 (80%)	0.138
Borderline	39 (21.4%)	28 (27.7%)	7 (11.5%)	4 (20%)	
Abnormal	1 (0.5%)	1 (1%)	0(0%)	0 (0%)	
Depression					
Normal	114 (62.6%)	59 (58.4%)	42 (68.9%)	13 (65%)	0.764
Borderline	47 (25.8%)	29 (28.7%)	13 (21.3%)	5 (25%)	
Abnormal	21 (11.5%)	13 (12.9%)	6 (9.8%)	2 (10%)	
Anxiety					
Normal	71 (39%)	41 (40.6%)	25 (41%)	5 (25%)	0.143
Borderline	60 (33%)	28 (27.7%)	25 (41%)	7 (35%)	
Abnormal	51 (28%)	32 (31.7%)	11 (18%)	8 (40%)	
Anger-hostility					
Normal	108 (59.3%)	56 (55.4%)	40 (65.6%)	12 (60%)	0.250
Borderline	45 (24.7%)	24 (23.8%)	14 (23%)	7 (35%)	
Abnormal	29 (15.9%)	21 (20.8%)	7 (11.5%)	1 (5%)	
Phobic-anxiety					
Normal	91 (50%)	49(48.5%)	34 (55.7%)	8 (40%)	0.096
Borderline	47 (25.8%)	21(20.8%)	81 (29.5%)	8 (40%)	
Abnormal	44 (24.2%)	31(30.7%)	9 (14.8%)	4 (20%)	
Paranoid ideation					
Normal	117 (64.3%)	64(63.4%)	44 (72.1%)	9 (45%)	0.064
Borderline	46 (25.3%)	24(23.8%)	12 (19.7%)	10 (50%)	
Abnormal	19 (10.4%)	13(12.9%)	5 (8.2%)	1 (5%)	
Psychosis					
Normal	103 (56.6%)	53(52.5%)	42 (68.9%)	8 (40%)	0.053
Borderline	47 (25.8%)	29(28.7%)	13 (21.3%)	5 (25%)	
Abnormal	32 (17.6%)	19(18.8%)	6 (9.8%)	7 (35%)	

PCL-5: Post traumatic Stress Disorder Checklist. **PSQI:** Pittsburg Sleep Quality Index.
Chi test and ANOVA test used for statistical Analysis (significant *P* value <0.05).

Table 3
Multivariate logistic regressions assessing the association between risk factors of sleep impairment and PTSD in COVID-19 patients.

Variable	Sleep Quality Impairment		PTSD	
	Odds ratio	*P* value	Odds ratio	*P* value
Gender				
Female	1.22	0.68	0.59	0.30
Age (years)[1]				
18 −30	0.47	0.23	0.53	0.30
31 −60	1.58	0.37	1.03	0.94
Marital status[2]				
Single	1.29	0.77	0.74	0.72
Married	1.17	0.84	0.23	0.07
Divorce			2.48	0.41
Education[3]				
Reading and writing	1.18	**0.001**	1.12	**0.017**
Elementary school	0.11	**0.013**	0.82	0.80
High school	0.11	0.013	0.26	0.07
Smoking state	0.68	0.43	0.40	0.07
Duration of admission[4]				
12 days or less	1.41	0.37	1.013	0.97
Oxygen aids	5.28	**0.001**	1.36	0.53
Mechanical ventilation	1.33	0.73	0.23	0.06
Comorbidity				
DM	1.24	**0.035**	1.25	0.71
HTN	0.59	0.51	1.02	0.97
CVD	3.03	0.201		
Severity[5]				
Non severe group	1.18	0.80	2.53	0.17
Severe group	5.28	**0.001**	0.32	0.60
laboratory				
ANC	0.734	0.54	1.08	0.87
NLR	1.34	0.47	2.61	**0.031**
HB	1.5	0.26	0.87	0.72
Platelet	0.55	0.21	0.79	0.60

ANC: Absolute neutrophilic count**, CVD:** Cerebro-Vascular disease**, DM:** Diabetes**, HB:** Hemoglobin**, HTN:** Hypertension, **NLR**: Neutrophil Lymphocyte Ratio, **PTSD**; Post Traumatic Stress Disorder.

[1] reference group is age group more than 60 years.
[2] reference group is Widow.
[3] reference group is higher education.
[4] reference group is more than12 days.
[5] reference group is critical group.
P value is significant if< 0.05.

of anxiety and OCD were 29.5% and 28.2% respectively while the incidence of depression was 68.3% (Gellan et al., 2021). A cohort study that followed COVID-19 patients for up to 90 days showed broad-based but not uniform psychiatric effects of COVID-19. In 14 to 90 day after COVID-19 diagnosis the incidence of mental health disorders was 18%of which 5% was first diagnosed. In addition, anxiety disorders were found to be more common than mood disorders. This study, however, did not find a link between post-COVID-19 anxiety and the post-traumatic stress disorder-like picture. In addition, it was discovered that rates of insomnia were extremely high among patients, possibly due to circadian disruptions following COVID-19 infection (Taquet et al., 2021).

Regarding the severity of COVID-19 infection, the critical group had the highest percentages of the probable PTSD response and abnormal responses in anxiety and psychosis subscales. Regarding PTSD, a previous study observed an increase PTSD symptoms 3 months after suffering from a critical illness that necessitated ICU admission (Cuthbertson et al., 2004), and another research observed that 14% of patients had severe PTSD symptoms six months after a serious condition that necessitated mechanical ventilation (Girard et al., 2007). According to anxiety, a cohort study followed a patient with COVID-19 up to 90 days reported an increase in the frequency of anxiety disorders (Taquet et al., 2021). Many factors are associated with anxiety after critical illness, such as an inability to communicate, lack of family, and the removal of mechanical ventilation (Shoar et al., 2016). Regarding psychosis, many reports observed the presence of psychosis in patients with COVID19 infection (Ferrando et al., 2020; Rentero et al., 2020; Smith et al., 2020). Severance et al. discovered that patients with psychotic symptoms had significantly higher IgG levels for two coronavirus strains (HKU1 and NL63) (Severance et al., 2011).

In the present study the non-severe patients had the highest percentage in many psychiatric illnesses such as somatization, Obsessive-compulsive, depression, phobic anxiety, Anger-hostility, and paranoid ideation in compared to critical and severe group. This group was more vulnerable to psychosocial stressors as self-isolation and medication at home, self-observation for any complication that could happen to them, fear of transmission of the infection to the family, and the possibility of recurrent COVID19 infection after recovery. Furthermore, Troyer et al. propose direct infection, blood circulation, neuronal involvement, hypoxic injury, immune injury, and ACE2 binding as potential causes of coronavirus nervous system damage (Troyer et al., 2020).

CRP levels correlate with the degree of inflammation and increase parallel to the increase in the largest pneumonia lesion diameter in COVID-19 patients (Wang, 2020); this supports our findings. CRP is the least in the non-severe group. On the other hand, we reported that the D-dimer was higher in the critical group. D-dimer >2 was found in an early study to be the only factor associated with mortality in COVID-19 patients (Yao et al., 2020).

In the critical group, it was observed that ferritin level was higher compared to other studied groups. A large meta-analysis found that high ferritin levels were associated with severe conditions and adult respiratory distress syndrome (ARDS) (Cheng et al., 2020). However, Wu et al. found that ferritin was neither associated with ARDS nor severe cases of COVID-19 (Wu et al., 2020). Biological factors that overlap with mental disorders and COVID-19 infection could also be involved (Wang et al., 2021), Inflammation is one of these factors. It has been linked to the pathogenesis of depression (Beurel et al., 2020), schizophrenia (Müller, 2018), and bipolar disorder (Benedetti et al., 2020), and also the systemic manifestations of COVID-19 infection (Steardo et al., 2020).

Multivariate logistic regression had been conducted to detect possible independent predictors for various psychological disorders 6 months after COVID-19 diagnosis. Female sex was an independent predictor for anxiety, phobic -anxiety, paranoid ideation, and psychosis, in line with many previous studies where females are consistently more prevalent due to biological factors and sex hormones (Lebron-Milad and Milad, 2012).

Age as a predictor for psychiatric disorders after COVID-19 infection has variable impacts, ages less than sixty had less risk for anxiety, phobic anxiety, paranoid ideation, and OCD. In contrast, those aged less than thirty were less liable to depression. In considering the general population, many previous studies found the reduced frequency of anxiety with younger age (Flint et al., 2010; Wells et al., 2006), which could be partially explained by social believes of higher death risk in the elderly.

In considering marital status as a predictor for psychiatric disorders after COVID-19, in the present study, being married or single were the only social states significantly associated with reduced risk of paranoid ideation than the widow and divorced persons. Marriage is a form of social support associated with less liability to psychological disorders (Flint et al., 2010). Divorce rates increased with higher levels of paranoid symptoms in a sample of middle-aged adults investigated in a previous study (Disney et al., 2012).

According to our observations, educational levels are just read and write predict the development of abnormal sleep, PTSD, phobic anxiety, paranoid ideation, and psychosis. Adults' educational attainment indirectly impacts their economic resources, social status, social networks, and health behaviour, leading to special psychological impacts.

Smoking is an extensively studied predictor of psychiatric abnormalities (Dome et al., 2010), with potential explanatory models including the effects of smoking on neurotransmitters, neurobiology, respiratory health, and autonomic control (Preter and Klein, 2008). In the current study, smoking was an independent predictor for OCD. In general, OCD patients have low rates of smoking (Bejerot and Humble,

Table 4
Multivariate logistic regressions assessing the association between risk factors somatization, anxiety, depression, and obsessive-compulsive disorder in COVID-19 patients.

Variable	Somatization Odds ratio	*P* value	Obsession Odds ratio	*P* value	Depression Odds ratio	*P* value	Anxiety Odds ratio	*P* value
Gender								
Female	0.907	0.84	1.134	0.794	1.757	0.263	4.404	**0.004**
Age (years)[1]								
18 −30	0.57	0.37	0.220	**0.012**	0.175	**0.005**	0.106	**0.000**
31 −60	0.56	0.27	0.298	**0.017**	0.813	0.698	0.186	**0.002**
Marital status[2]								
Single	1.120	0.910	1.212	0.816	0.368	0.247	0.522	0.484
Married	0.650	0.642	0.810	0.785	0.264	0.102	0.414	0.315
Divorce	0.570	0.683	2.111	0.468				
Education[3]								
Reading and writing	2.216	0.136	0.497	0.131	0.559	0.279	0.410	0.053
Elementary school			0.652	0.542	0.308	0.204	0.500	0.376
High school	1.689	0.467	0.779	0.669	1.212	0.776	3.403	0.130
Smoking state	0.86	0.78	2.926	**0.028**	1.825	0.237	2.330	0.096
Duration of admission[4]								
12 days or less	1.14	0.72	1.175	0.660	1.035	0.927	1.611	0.196
Oxygen aids	1.4	0.48	2.039	0.122	1.747	0.238	1.343	0.546
Mechanical ventilation	4.36	0.15	2.336	0.311	1.548	0.610	1.322	0.729
Comorbidity								
DM	1.12	0.85	1.681	0.358	4.101	**0.039**	1.095	0.877
HTN			0.723	0.662	0.713	0.662	0.818	0.775
CVD	0.33	0.31	0.150	0.061	0.785	0.799	0.346	0.272
Severity[5]								
Non severe group	0.63	0.56	3.699	0.081	2.618	0.154	6.700	**0.017**
Severe group	0.36	0.21	1.415	0.629	1.456	0.570	3.705	0.078
laboratory								
ANC	0.860	0.780	1.744	0.207	0.625	0.317	1.252	0.631
NLR	1.593	0.259	1.498	0.275	1.295	0.531	0.940	0.875
HB	2.019	0.053	1.674	0.113	2.691	**0.008**	1.726	0.107
Platelet	0.604	0.298	0.830	0.635	0.766	0.531	1.211	0.644

* **ANC:** Absolute neutrophilic count**, CVD:** Cerebro-Vascular disease**, DM:** Diabetes**, HB:** Hemoglobin**, HTN:** Hypertension, **NLR**: Neutrophil Lymphocyte Ratio, **PTSD**; Post Traumatic Stress Disorder.

[1] reference group is age group more than 60 years.
[2] reference group is Widow.
[3] reference group is higher education.
[4] reference group is more than12 days.
[5] reference group is critical group.
p-value is significant if <0.05.

1999). This might be due to the fear of COVID-19 infection and its complication in smoker persons who mostly have chest and lung troubles from smoking.

Oxygen aids and the need for mechanical ventilation were also included in the univariate and multivariate analysis, revealing a predictor role of the need for oxygen aids in relation to sleep abnormalities and phobic-anxiety disorders. In contrast, mechanical ventilation was only a predictor for phobic-anxiety. Using tools to increase oxygen level in patients usually associated with unpleasant experience as pain, thirst (Puntillo et al., 2010), fears of left alone, choking, fear about being out of oxygen (de Haro et al., 2019). Patients who are mechanically ventilated are unable to communicate and express their emotions verbally or validate clinicians' assessments (Campbell and Happ, 2010). Comorbid conditions as DM and HTN were evaluated in our study in relation to the severity of COVID-19 infection and as predictors for psychiatric disorders. In agreement with many studies, the non-severe group in our research had the least number of patients suffering from DM and HTN (Resnick et al., 2003; Zambanini et al., 1999). DM was an independent predictor for depression, sleep abnormalities, and phobic anxiety, and psychosis. In multiple researches, comorbid conditions were associated with increased severity, morbidity, and chronicity of depressive disorders (Rush et al., 2005). Diabetes can cause sleep disturbances as a result of the disease's adverse effects on central respiratory control (Resnick et al., 2003). Moreover, in a large study, more anxiety-depression and phobic symptoms were also associated with diabetes (Zambanini et al., 1999).

According to our results, high NLR was a predictor for PTSD and psychosis. This is supported by a previous study in which elevated NLR predicts are associated with poor outcomes in COVID-19 patients (Bo et al., 2020; McLean et al., 2011). So, increase NLR predict the increase of severity of COVID-19 infection that consider as threated life condition which predict PTSD afterwhile.

This study has limitations; studying many factors needs a larger sample size to validate the results. Additionally, long-time assessment after COVID19 infection allows for too many confounders as psychological disorders are greatly affected by social, economic, and even private life changes. In this study.

In conclusion, according to our observations, COVID-19 infection has its unique psychological impact extending to 6 months after diagnosis. Poor sleep quality, somatization, and anxiety are the most common mental illness in post Covid19. The critical group is common associated with PTSD, anxiety, and psychosis. Being female, diabetic, having oxygen support or mechanically ventilated, and high NLR level are more vulnerable for mental illness in post COVID19.

Funding

None.

CRediT authorship contribution statement

Gellan K. Ahmed: Investigation, Formal analysis, Writing – original draft, Visualization. **Eman M. Khedr:** Conceptualization, Supervision, Project administration. **Dina A. Hamad:** Data curation, Visualization,

Table 5
Multivariate logistic regressions assessing the association between risk factors Phobic-anxiety, Paranoid ideation, and Psychosis in COVID-19 patients.

Variable	Phobic- anxiety		Paranoid ideation		Psychosis	
	Odds ratio	P value	Odds ratio	P value	Odds ratio	P value
Gender						
Female	3.15	**0.026**	3.17	**0.025**	3.29	**0.022**
Age (years)[1]						
18 −30	0.14	**0.002**	0.122	**0.001**	0.419	0.16
31 −60	0.29	**0.01**	0.26	**0.017**	0.357	0.06
Marital status[2]						
Single	0.18	0.16	0.12	**0.02**	0.43	0.327
Married	0.15	0.096	0.14	**0.03**	0.70	0.664
Divorce	0.66	0.77	0.57	0.62		
Education[3]						
Reading and writing	1.368	**0.03**	1.23	**0.01**	1.162	**0.002**
Elementary school	0.953	0.947	0.64	0.55	0.37	0.265
High school	1.09	0.881	1.05	0.92	0.433	0.899
Smoking state	1.77	0.25	0.41	0.14	2.123	0.139
Duration of admission[4]						
less than 12 days	0.97	0.95	1.14	0.72	0.952	0.89
Oxygen aids	3.2	**0.019**	1.41	0.46	2.08	0.134
Mechanical ventilation	7.9	**0.05**	2.6	0.33	3.35	0.222
Comorbidity						
DM	5.89	**0.007**	1.67	0.40	7.48	**0.005**
HTN	0.60	0.54	0.68	0.62		
CVD	2.64	0.39	1.72	0.60	0.48	0.521
Severity[5]						
Non severe group	17.4	**0.001**	8.9	**0.003**	2.614	0.192
Severe group	4.63	**0.05**	6.7	**0.009**	2.63	0.176
laboratory						
ANC	0.82	0.65	0.79	0.60	1.9	0.173
NLR	1.13	0.73	1.27	0.54	2.08	0.064
HB	1.148	0.67	1.62	0.16	1.04	0.89
Platelet	1.06	0.86	1.04	0.91	1.3	0.53

ANC: Absolute neutrophilic count, **CVD:** Cerebro-Vascular disease, **DM:** Diabetes, **HB:** Hemoglobin, **HTN:** Hypertension, **NLR**: Neutrophil Lymphocyte Ratio, **PTSD**; Post Traumatic Stress Disorder.

[1] reference group is age group more than 60 years.
[2] reference group is Widow.
[3] reference group is higher education.
[4] reference group is more than12 days.
[5] reference group is critical group.
p value is significant if <0.05.

Investigation. **Taghreed S. Meshref:** Data curation, Visualization, Investigation. **Mustafa M. Hashem:** Methodology, Supervision, Project administration. **Mai M. Aly:** Investigation, Formal analysis, Writing – original draft, Visualization.

Declaration of Competing Interest

The authors declare no conflicts of interests.

Acknowledgement

None

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2021.114243.

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