Review Psikiyatride Güncel Yaklaşımlar-Current Approaches in Psychiatry 2024; 16(2):203-209
doi: 10.18863/pgy.1181901

Psychotic Process in the COVID-19 Pandemic: Dopamine Effect

COVID-19 Pandemisinde Psikotik Süreç: Dopamin Etkisi

Ayşegül Dönmez[1], Gülseren Keskin[1]

[1]Ege University, Izmir

ABSTRACT

The global impact of severe acute respiratory syndrome COVID-19 has extended beyond physical health, significantly affecting mental well-being worldwide. Amid the pandemic's initial wave, COVID-19 patients exhibited symptoms of post-traumatic stress disorder and notably depressive symptoms. Alongside manifestations like delirium, confusion, agitation, and altered consciousness, prevalent mental health issues during the pandemic encompassed depression, anxiety, and insomnia. Individuals recovering from COVID-19 may face enduring psychiatric challenges post-hospital discharge, potentially linked to dopamine. Dopaminergic receptors might heighten the susceptibility of certain viruses to bind with the central nervous system, instigating viral encephalitis in the virus's early infection stages. Dopamine could also disrupt the human basal carotid body's respiratory response to hypoxia. Additionally, the virus could manipulate the immune system by elevating dopamine levels, facilitating viral entry. These findings emphasize the significance of considering dopamine's role in the diagnosis, treatment, and care of COVID-19 patients and those with diagnosed psychosis. Tailored interventions are crucial for individuals exhibiting distinctive features. Another intriguing aspect worthy of investigation is whether dopamine confers protection against COVID-19. This review article aims to elucidate the intricate relationship between the impactful COVID-19 pandemic and dopamine, shedding light on its potential implications and avenues for further exploration.
Keywords: COVID-19, psychosis, dopamine, pandemic

ÖZ

Ağır akut solunum yolu sendromu COVID-19'un küresel etkisi, fiziksel sağlığın ötesine geçerek dünya çapında ruh sağlığını önemli ölçüde etkilemiştir. Pandeminin ilk dalgasının ortasında, COVID-19 hastaları travma sonrası stres bozukluğu ve özellikle depresif semptomlar sergilemiştir. Pandemi sırasında deliryum, konfüzyon, ajitasyon ve bilinç değişikliği gibi belirtilerin yanı sıra depresyon, anksiyete ve uykusuzluk gibi yaygın ruh sağlığı sorunları da ortaya çıkmıştır. COVID-19'dan iyileşen bireyler, hastaneden taburcu olduktan sonra, dopamine bağlı olması muhtemel kalıcı psikiyatrik zorluklarla karşılaşabilirler. Dopaminerjik reseptörler, belirli virüslerin merkezi sinir sistemine bağlanma duyarlılığını artırarak virüsün erken enfeksiyon aşamalarında viral ensefaliti tetikleyebilir. Dopamin ayrıca insan bazal karotis cisimciğinin hipoksiye karşı solunum tepkisini de bozabilir. Ayrıca virüs, dopamin düzeylerini yükselterek bağışıklık sistemini etkileyebilir ve viral girişi kolaylaştırabilir. Bu bulgular, COVID-19 hastalarının ve psikoz teşhisi konmuş kişilerin tanı, tedavi ve bakımında dopaminin rolünün dikkate alınmasının önemini vurgulamaktadır. Ayırt edici özellikler sergileyen bireylere özgü müdahalelerde bulunulması çok önemlidir. Araştırmaya değer bir başka ilgi çekici konu da dopaminin COVID-19'a karşı koruma sağlayıp sağlamadığıdır. Bu derlemede, Covid-19 salgını ile dopamin arasındaki karmaşık ilişkinin aydınlatılması, potansiyel sonuçlarına ve daha fazla araştırmaya yönelik olası noktalara ışık tutulması amaçlanmaktadır.
Anahtar sözcükler: COVID-19, psikoz, dopamin, pandemi

Introduction

The severe acute respiratory syndrome COVID-19 has impacted the entire world, prompting governments worldwide to employ various measures in combating the virus. With 415 million confirmed cases and 5.83 million deaths attributed to COVID-19 (WHO 2022), the pandemic has not only resulted in significant casualties and infections but has also posed substantial challenges globally due to widespread quarantine measures (Vincent and Creteur 2020).

This pandemic has jeopardized both physical and mental health, as evidenced by numerous scientific publications exploring potential direct effects on the mental health of COVID-19 patients (Attademo and Bernardini 2020, Loch et al. 2020). Clinical evidence indicates that individuals infected with COVID-19 might

Address for Correspondence: Gülseren Keskin, Ege University Atatürk Vocational School of Health Services, Izmir, Turkiye
E-mail: gulseren.keskin@ege.edu.tr
Received: 15.05.2023 | **Accepted:** 08.08.2023

experience both short-term and long-term mental health issues. Notably, during the initial pandemic wave, COVID-19 patients displayed high levels of post-traumatic stress disorder symptoms and markedly elevated depressive symptoms (Vindegaard and Benros 2020). Depression, anxiety, insomnia, delirium, confusion, agitation, and altered consciousness were among the prevalent mental health challenges during this period. Survivors of critical illness following COVID-19 hospitalization face the risk of enduring psychiatric impairments such as persistent amnestic disorders and prolonged depression (Attademo and Bernardini 2020, Loch et al. 2020).

Research suggests that neuropsychiatric symptoms tend to persist after COVID-19, encompassing sleep disorders, fatigue, depression, anxiety, amnestic syndromes, and post-traumatic stress (Premraj et al. 2022, Colizzi et al. 2023). Reports indicate that a considerable number of severe acute respiratory distress syndrome patients with COVID-19 exhibit impaired memory, attention, concentration, or mental processing speed within a year (Rogers et al. 2020). These patients often manifest additional neurological symptoms like loss of smell or taste, muscle pain, stroke, headaches, impaired consciousness, dizziness, and seizures (Aydemir et al. 2021). Moreover, COVID-19 patients may also undergo cytokine storm syndrome, a crucial indicator of blood-brain barrier disruption (Filatov et al. 2020). Patients with severe disease criteria (SpO2 <94%, PaO2/FiO2 <300 mm Hg, respiratory rate >30 breaths/min, or lung infiltrates >50%) are at risk of rapid clinical deterioration (Safiabadi et al. 2021).

Several factors contribute to the psychiatric outcomes of the COVID-19 pandemic, including its broader societal impact, physical distancing measures, and restrictive actions like quarantine. The potential etiological mechanisms underlying the neuropsychiatric consequences of coronavirus infection likely encompass multiple components, although a complete understanding is still lacking. Immediate effects of viral infection on the central nervous system (CNS) could involve cerebrovascular disease, physiological disruptions, inflammatory responses, social isolation, psychological distress from severe illness, fear of infecting others, and clinical or social stigmatization (Ghebreyesus 2020, Rogers et al. 2020).

While existing literature assesses the impact of COVID-19 on mental health disorders, the relationship between COVID-19 psychotic symptoms and dopamine remains unexplored. Hence, this study aims to fill this gap by investigating the association between the profound COVID-19 pandemic and dopamine. It seeks to analyze the incidence of COVID-19 and psychotic symptoms, the impact of proinflammatory cytokine release on the dopaminergic system, and its role in the development of neuropsychiatric symptoms.

Relationship between Psychosis and COVID 19

The literature has explored the occurrence of psychotic symptoms during historical pandemic outbreaks. Observations over five years have shown an improvement in most of these symptoms, with Karl Menninger's case series on psychosis following the Spanish flu in 1919 being a well-known example (Menninger 1919). Until the 1990s, viral respiratory infections were considered a risk factor for schizophrenia (Yolken and Torrey 1995). Now, humanity confronts a COVID-19 pandemic of alarming proportions, initially perceived as a respiratory virus but later found to harm various organ systems, including the nervous system (Wu et al. 2020).

A systematic review by Chaudhary et al. (2022) assessing psychotic symptoms in COVID-19 patients revealed that 93% exhibited delusions like grandiosity, paranoia, mysticism, and reference delusions, with 72.7% experiencing auditory hallucinations. Excessive stress in individuals with psychosis can exacerbate all symptoms, while social limitations may trigger delusional thinking. Chronic stress is a crucial factor in psychosis development. Studies on patients with psychosis and those at high risk have shown neural reactivity changes to stress in limbic and paralimbic brain areas (Vargas et al. 2020, Vaessen et al. 2023). Researchers suggest that life events such as COVID-19 could trigger the onset of psychosis (Nugent et al. 2015, Berger et al. 2018). Post-COVID infection, individuals preliminarily diagnosed with psychosis tend to be overly cautious and interpret inquiries about the disease from healthcare professionals as threatening. These misinterpretations may lead to increased feelings of danger, avoidance, and paranoia (Murray 2022).

The coronavirus is believed to access the central nervous system via the bloodstream or peripheral neurons using retrograde axonal transport (Wu et al. 2020). Angiotensin-converting enzyme-2 (ACE2) acts as the functional host receptor for SARS-CoV-2 and is involved in the renin-angiotensin-aldosterone system. Although ACE2 expression in the CNS is generally low, certain areas have comparatively higher expression, including dopamine and serotonin-related regions. These areas play a role in schizophrenia and may be linked to future psychopathology resulting from infection (Walker et al. 2018, Chen et al. 2021,).

COVID-19 down-regulates ACE2, which shares genetic similarity with dopamine decarboxylase, an enzyme in dopamine and serotonin synthesis (Nataf 2020). SARS-CoV-2 induces an immune response releasing proinflammatory cytokines, potentially associated with psychosis via an immediate increase and activated autoimmune mechanism (Yeşilkaya et al. 2021). The virus-induced cytokine storm, including high serum concentrations of certain cytokines, may influence neurotransmitter levels, affecting dopamine, serotonin, and norepinephrine reuptake. This cascade might result in NMDA receptor hypofunction and altered dopamine production (Grover et al. 2022). Furthermore, catatonic features in some cases of COVID-19 may contribute to akinetic catatonia due to the destruction of associative functions, particularly the connections of the frontal lobes with the parietal cortex and motor areas (Ellul and Choucha 2015).

Inflammation Process in the Development of Psychosis

Stress is particularly effective during both prenatal and postnatal neurodevelopment. Prenatal submitted to maternal infection, pursued by psychological trauma during adolescence, poses a risk for the development of psychosis. Biological stressors disrupt hypothalamic-pituitary-adrenal (HPA) axis dysregulation. There is a decrease in cortisol levels, a decrease in hippocampal volume, and problems in dopamine and glutamate transmission (Debost et al. 2017, Pruessner 2017). Microglia, the brain's innate immune cells, secrete inflammatory cytokines in return for stress or infection and support disruptions in the HPA axis. Microglial overactivation also plays a role in schizophrenia and can result in abnormal synaptic pruning and changed neurotransmitter metabolism because of excessive cytokine emission (Raison et al. 2017).

Psychosis and Infections

Viruses both directly invade and damage the CNS through immune activation. Viruses have evolved a variety of strategies to gain access to the CNS. They infect leukocytes which convey them throughout the blood-brain barrier, exude retrograde axonal transport machinery from peripheral nerves, connect CNS endothelial proteins to gain entry, and invade the olfactory nerve. There is also proof that viruses change dopamine metabolism (Kulaga, Miller 2021) and influence glutamate transmission through molecular mimicry at N-methyl-d-aspartate (NMDA) receptors (Kannan et al. 2017), triggering psychotic symptoms (Kępińska et al. 2020).

Psychosis and COVID-19 Demyelination

Some studies suggest that COVID-19 could potentially exacerbate demyelinating diseases (Maury et al. 2021). Demyelination, which involves the decline of central nervous system (CNS) white matter, primarily composed of myelin, is thought to be a contributing factor in the pathophysiology of schizophrenia (Mighdoll et al. 2015). Additionally, there's evidence indicating that demyelination resulting from COVID-19 might significantly impair cognitive functions in the subsequent years (Xu and Li 2011).

Psychosis and Dopamine

Psychotic symptoms exist in various mental disorders like schizophrenia, bipolar disorder, and depression. In schizophrenia, there are positive symptoms, such as hallucinations and delusions, affective signs, and negative symptoms, such as cognitive deficits and social withdrawal. The dopamine system has been involved in the pathophysiology of schizophrenia and psychosis centrally for over fifty years, mainly because antipsychotic drugs utilize their effects by restricting the D2 dopamine receptor (D2R). In vivo molecular imaging studies using positron emission tomography (PET) have provided ample evidence of increased presynaptic dopamine synthesis capacity and amphetamine-induced dopamine release in schizophrenia. Increases in presynaptic dopamine synthesis capacity have also been observed in individuals at high risk of developing schizophrenia; in particular, higher levels have been observed in individuals who subsequently develop a psychotic disorder comparing those who do not (Matheson et al. 2020). Abnormal striatal dopamine signaling specifically boosted presynaptic dopamine synthesis capacity, was associated with psychotic symptoms (McCutcheon et al. 2019). Although most studies have concentrated on the link to positive signs, striatal dopamine alterations are related to cognitive and negative symptoms seen in psychotic disorders (McCutcheon et al. 2020). Abnormal striatal dopamine signaling, specifically increased presynaptic dopamine synthesis capacity, has been associated with psychotic symptoms. It has been determined that dopamine synthesis capacity is particularly abnormal in the striatum regions, and dopamine dysfunction is firmly related to the severity of negative symptoms (McCutcheon 2020). The subject that must be investigated is whether individuals who have never been diagnosed with COVID-19 will be protected from COVID-19 if dopamine production increases.

Dopamine and Viruses

Dopaminergic receptors are known to be involved in different virus infections (Khalefah and Kahalifah 2020). Japanese encephalitis virus (JEV) has been reported to agitate the blood-brain barrier and cause viral encephalitis. JEV utilizes dopamine signaling to ease the infectious process by significantly increasing dopamine levels; this increase may be associated with the sensitization of neighboring cells to JEV through stimulation of the dopamine receptor D2 (D2DR) (Gaskill et al. 2014, Simanjuntak et al. 2017). Many clinical follow-ups assist this hypothesis.

Firstly, neurologic manifestations usually occur following the diagnosis of COVID-19, akin to some neurotropic microbial infections. Dopaminergic receptors may boost the chances of some viruses connecting to the CNS to start viral encephalitis in the former phases of viral infection. Furthermore, the viral life cycle of SARS-CoV-2 can be improved by being of high levels of catecholamine, probably via connecting to dopaminergic receptors and boosting the likelihood of viral entry (Russel et al. 2020).

Secondly, boosted dopamine lowers oxygen levels, particularly when considering "happy hypoxemia" in a way correlated with COVID-19. This concept, known as "silent hypoxemia" or "happy hypoxia," is used for COVID-19 patients with severe, life-threatening oxygen levels but no signs of shortness of breath. That happens because dopamine can decrease the respiratory return of human basal carotid body activity to hypoxia. Accordingly, SARS-CoV-2 and dopamine may share responsibility for disrupted ventilation. It is also noted to reduce oxygen levels seen in COVID-19 patients. Some drugs (e.g. haloperidol) hamper the return to exogenous dopamine but do not change the ventilatory return during normoxia or hypoxia, proposing that endogenous dopamine does not share in stating the steady-state chemoreceptor (Russel et al. 2020).

Third, dopamine is a regulator of immune function. The virus can influence the immune system by boosting dopamine levels to boost the probability of viral entry. Dopamine shows action on D1-like receptors or D2-like receptors to stimulate or inhibit cAMP production, respectively. The main effect of dopamine on lymphocytes is to reduce their activation level. Boosted D1-like receptor agonists such as dopamine can stimulate cAMP production, often suppressing innate immune functions.

Furthermore, increased D2-like receptors result in inhibition of the adaptive immune response. The major problem is the exacerbation of proinflammatory reactions, which will deteriorate the pathogenic situation. Depletion of T cells can cause the progression of COVID-19. Dopamine is vital in diminishing host immunity and increasing the likelihood of serious complications (Russel et al. 2020).

In total, COVID-19 and its long-term adverse effects can result in abnormal processing of perceptions. Novel variants of SARS-CoV-2 may affect perceptual pathways. The angiotensin-converting enzyme-2 (ACE-2) receptor, which can modulate smell and taste perception, has been identified as a potential viral receptor. Such interaction may impair chemosensory perception (Vaira et al. 2020). In addition, SARS-CoV-2 may agitate the body's perception of external stimuli by affecting perceptual nuclei and pathways in the brainstem where the virus can infiltrate through ACE-2 receptors (Yeşilkaya and Balcıoğlu 2020).

Prolonged COVID Syndrome: Neuropsychiatric Symptoms

Prolonged COVID is a term used to describe the disease in the COVID-19 patient group or people who have recovered from COVID-19, where persistent effects of infection and neuropsychiatric symptoms persist for months pursuing acute infection. In the COVID-19 patient group, neuropsychiatric symptoms persisting for months after acute infection have been reported. The picture can be accompanied by fatigue, "brain fog," anxiety, depression, and psychosis (Graham et al. 2021, Lopez-Leon et al. 2021). That phenomenon is predicted to influence more than 80% of hospitalized patients (Graham et al. 2021). Remarkably, the long-term neuropsychiatric symptoms of COVID-19 can be seen even in mildly symptomatic individuals and develop into persistent symptoms in an estimated 10% of all patients (Kingstone et al. 2020, Rubin 2020). Inflammatory processes are considered to cause the development of mental disorders. Systemic inflammation may also cause psychological distress and risk of depression through dysregulation of proinflammatory cytokines that predict psychological distress. COVID-19 may act as a catalyst triggering neuroimmune dysregulation to increase the risk of depressive symptoms. In a group of older adults in the UK, those with high inflammation before the pandemic were at the highest risk of developing boosted depressive symptoms in the early phases of the COVID-19 crisis (Hamilton et al. 2021). Mazza et al. (2021) stated systemic inflammation may cause depressive symptomatology and cognitive impairment three months after acute COVID-19 infection. In line with all these

findings, there is a need to investigate the dopaminergic effect on COVID-19 infection. As a result, publications examining the relationship between prolonged COVID-19 syndrome and dopamine are needed.

Conclusion

The global impact of the COVID-19 pandemic is unmistakable, leaving a lasting impression not only due to its physical manifestations but also because of its profound psychological effects, which will likely remain a topic of discussion and research for years to come. Among the biochemical substances influencing these psychological effects, dopamine stands out as a key player in shaping the impact of COVID-19 on mental health. The dopaminergic relationship is predicted to contribute to the persistence of COVID-19 owing to its mental effects. It becomes crucial to investigate whether elevated dopamine levels in individuals offer protection against coronavirus transmission. Conversely, documented cases in the literature highlight instances of acute psychosis emerging in patients with no prior psychiatric history following COVID-19 infection (Watson et al. 2021, O'Leary and Keenmon 2023).

In essence, there is a prevailing view that psychotic symptoms might persist in individuals diagnosed with COVID-19 in the years to come. Understanding the role of dopamine in the cause-and-effect mechanisms underlying the mental symptoms of the COVID-19 pandemic is vital for devising optimal treatment strategies and preparing for potential future global health crises. In the diagnosis, treatment, and care of individuals affected by COVID-19 and those diagnosed with psychosis, it is imperative not to overlook these findings, ensuring that individuals with distinctive features receive appropriate interventions. Additionally, this underscores the necessity for long-term monitoring of these patients to explore the most effective treatment methods once acute symptoms have subsided.

References

Antonini V, Leta J, Teo KR (2020) Outcome of Parkinson's disease patients affected by COVID-19. Mov Disord, 35:905-908.

Atıcı Y, Elbaş Y, Bakır F, Yıldırımkaya MM (2021) COVID-19 Enfeksiyonunda ACE ve ACE2 reseptörlerinin potansiyel rolü. In COVID-19 Pandemisinde Tıbbi Biyokimyanın Artan Rolü. (Ed. D Yücel):57-62. Ankara, Türkiye Klinikleri.

Attademo L, Bernardini F (2021) Are dopamine and serotonin involved in COVID-19 pathophysiology? Eur J Psychiatry, 35:62–63.

Aydemir D, Türk Ö, Ceylan B, Yıldırım N, Baylam EÖ, Koçkar İN et al. (2021) COVID-19 ve nörolojik hastalıklar. SDÜ Tıp Fakültesi Derg, 1:235-240.

Berger M, Juster RP, Westphal S, Amminger GP, Bogerts B, Schiltz K et al. (2018) Allostatic load is associated with psychotic symptoms and decreases with antipsychotic treatmentin patients with schizophrenia and first-episode psychosis. Psychoneuroendocrinology. 90:35-42.

Chaudhary AMD, Musavi N B, Saboor S, Javed S, Khan S, Naveed S (2022) Psychosis during the COVID-19 pandemic: A systematic review of case reports and case series. J Psychiatr Res, 153:37–55.

Chen R, Wang K, Yu J, French L, Chen Z, Wen C et al. (2021) The spatial and Cell-type distribution of SARS-CoV-2 receptor ACE2 in the human and mouse brains. Front Neurol, 11:573095.

Colizzi M, Peghin M, De Martino M, Bontempo G, Gerussi V, Palese A et al (2023) Mental health symptoms one year after acute COVID-19 infection: Prevalence and risk factors. Rev Psiquiatr Salud Ment, 16:38–46.

Debost JP, Larsen JT, Munk-Olsen T, Mortensen PB, Meyer U, Petersen L et al (2017) Joint effects of exposure to prenatal infection and peripubertal psychological trauma in schizophrenia. Schizophr Bull. 43:171–179.

Ellul P, Choucha W (2015) Neurobiological approach of catatonia and treatment perspectives. Front Psychiatry, 6:182-185.

Filatov A, Sharma P, Hindi F, Espinosa P (2020) Neurological complications of coronavirus Disease (COVID-19): Encephalopathy. Cureus, 12:e7352.

Gaskill PJ, Yano HH, Kalpana GV, Javitch JA, Berman JW (2014) Dopamine receptor activation increases HIV entry into primary human macrophages. PloS One, 9:e108232.

Ghebreyesus TA (2020) Addressing mental health needs: an integral part of COVID-19 response. World Psychiatry 19:129-130.

Grover S, Rani S, Kohat K, Kathiravan S, Kathiravan S, Patel G, Sahoo S, et al (2022) First episode psychosis following receipt of first dose of COVID-19 vaccine: A case report. Schizophr Res, 241:70–71.

Hamilton OS, Cadar D, Steptoe A (2021) Systemic inflammation and emotional responses during the COVID-19 pandemic. Transl Psychiatry, 11:626.

Kannan G, Gressitt KL, Yang S, Stallings CR., Katsafanas E, Schweinfurth LA (2017) Pathogen-mediated NMDA receptor autoimmunity and cellular barrier dysfunction in schizophrenia. Transl Psychiatry, 7:e1186.

Kępińska AP, Iyegbe CO, Vernon AC, Yolken R, Murray RM, Pollak TA (2020) Schizophrenia and influenza at the centenary of the 1918-1919 Spanish influenza pandemic: Mechanisms of psychosis risk. Front Psychiatry,11:72.

Kępińska AP, Iyegbe CO, Vernon AC, Yolken, R, Murray RM, Pollak TA (2020) Schizophrenia and ınfluenza at the centenary of the 1918-1919 Spanish ınfluenza pandemic: mechanisms of psychosis risk. Front Psychiatry, 11:72.

Khalefah MM, Khalifah AM (2020) Determining the relationship between SARS-CoV-2 infection, dopamine, and COVID-19 complications. J Taibah Univ Med Sci, 15:550–553.

Kulaga SS, Miller C (2021) Viral respiratory infections and psychosis: A review of the literature and the implications of COVID-19. Neurosci Biobehav Rev, 127:520–530.

Li Y, Bai W, Hashikawa T (2020) The neuroinvasive potential of SARS-CoV2 may play a role in the respiratory failure of COVID-19 patients J Med Virol, 92:552-555.

Loch A A, Mota NB, Rössler W, Gattaz WF (2022) Exacerbation of psychosis risk during the COVID-19 pandemic: The disproportionate impact on the lower income population. Psychiatry Res, 307:114319.

Matheson G J, Plavén-Sigray P, Louzolo A, Borg, J, Farde L, Petrovic P et al (2020). Dopamine D1 receptor availability is not associated with delusional ideation measures of psychosis proneness. Schizophr Res, 222:175–184.

Maury A, Lyoubi A, Peiffer-Smadja N, de Broucker T, Meppiel E (2021) Neurological manifestations associated with SARS-CoV-2 and other coronaviruses: A narrative review for clinicians. Rev Neurol, 177: 51–64.

McCutcheon RA, Abi-Dargham A, Howes OD (2019) Schizophrenia, dopamine and the striatum: From biology to symptoms. Trends Neurosci, 42:205–220.

McCutcheon RA, Jauhar S, Pepper F, Nour MM, Rogdaki M, Veronese M et al (2020) The topography of striatal dopamine and symptoms in psychosis: An integrative positron emission tomography and magnetic resonance imaging study. Biol Psychiatry Cogn Neurosci Neuroimaging, 5:1040-1051.

McCutcheon RA, Krystal JH, Howes OD (2020). Dopamine and glutamate in schizophrenia: biology, symptoms and treatment. World Paychiatry, 19:15–33.

Menninger KA (1919) Psychoses associated with influenza. JAMA, 72:235-241.

Mighdoll MI, Tao R, Kleinman JE, Hyde TM (2015) Myelin, myelin-related disorders, and psychosis. Schizophr Res, 161:85–93.

Murray A (2022) Heightened risk factors in the midst of the pandemic: Supporting individuals with psychosis during COVID-19. Perspect Psychiatr Care, 58:164–169.

Nataf S (2020) An alteration of the dopamine synthetic pathway is possibly involved in the pathophysiology of COVID-19. J Med Virol, 92:1743–1744.

Nugent KL, Chiappelli J, Rowland LM, Hong LE (2015) Cumulative stress pa-thophysiology in schizophrenia as indexed by allostatic load. Psychoneuroendocrinology. 60:120-129.

O'Leary KB, Keenmon C (2023) New-onset psychosis in the context of COVID-19 infection: An illustrative case and literature review. J Acad Consult Liaison Psychiatry, 64:383-391.

Premraj L, Kannapadi NV, Briggs J, Seal SM, Battaglini D, Fanning J et al. (2022) Mid and long-term neurological and neuropsychiatric manifestations of post-COVID-19 syndrome: a meta-analysis. J Neurol Sci, 434:120162.

Pruessner M (2017) The neural diathesis-stress model of schizophrenia revisited: an update on recent findings considering illness stage and neurobiological and methodological complexities. Neurosci Biobehav Rev, 73:191-218.

Raison C, Reed R, Rook G, Chir B, Miller A (2017) Immune system and central nervous system interactions. In Kaplan & Sadock's Comprehensive Textbook of Psychiatry 10th ed. Vol.1 (Eds B J Sadock, P Ruiz, VA Sadock):178-200. Philadephia, PA, Lippincott Williams and Wilkins.

Rogers JP, Chesney E, Oliver D, Pollak TA, McGuire P, Fusar-Poli P et al (2020) Psychiatric and neuropsychiatric presentations associated with severe coronavirus infections: A systematic review and meta-analysis with comparison to the COVID-19 pandemic. Lancet Psychiatry, 7:611–627.

Russell B, Moss C, George G, Santaolalla A, Cope A, Papa S et al (2020). Associations between immune-suppressive and stimulating drugs and novel COVID-19-a systematic review of current evidence. Ecancermedicalscience, 14:1022.

Safiabadi Tali SH, LeBlanc JJ, Sadiq Z, Oyewunmi OD, Camargo C, Nikpour B et al (2021) Tools and techniques for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)/COVID-19 detection. Clin Microbiol Rev, 34:e00228-20.

Simanjuntak Y, Liang JJ, Lee YL, Lin YL(2017) Japanese encephalitis virus exploits dopamine D2 receptor-phospholipase C to target dopaminergic human neuronal cells. Front Microbiol, 8:651.

Vaessen T, Reininghaus U, Aubel E, Beijer-Klippel A, Steinhart H, Myin-Germeys I et al. (2023) Neural correlates of daily-life affective stress reactivity in early psychosis: A study combining functional MRI and experience sampling methodology. Schizophr Res, 255:93-101.

Vargas T, Conley RE, Mittal VA (2020) Chronic stress, structural exposures and neurobiological mechanisms: A stimulation, discrepancy and deprivation model of psychosis. Int Rev Neurobiol, 152:41–69.

Vincent JL, Creteur J (2020) Ethical aspects of the COVID-19 crisis: how to deal with an overwhelming shortage of acute beds. Eur Heart J Acute Cardiovasc Care, 9:248-252.

Vindegaard N, Benros ME (2020) COVID-19 pandemic and mental health consequences: Systematic review of the current evidence. Brain Behav Immun, 89:531–542.

Walker CK, Roche JK, Sinha V, Roberts RC (2018) Substantia nigra ultrastructural pathology in schizophrenia. Schizophr Res, 197:209–218.

Watson CJ, Thomas RH, Solomon T, Michael BD, Nicholson TR, Pollak TA (2021) COVID-19 and psychosis risk: Real or delusional concern?. Neurosci Lett, 741:135491.

WHO (2022) WHO Coronavirus (COVID-19) Dashboard. https://covid19.who.int/ (Accessed 01.03.2023)

Wu Y, Xu X, Chen Z, Duan J, Hashimoto K, Yang L et al (2020) Nervous system involvement after infection with COVID-19 and other coronaviruses. Brain Behav Immun, 87:18–22.

Xu H, Li XM (2011) White matter abnormalities and animal models examining a putative role of altered white matter in schizophrenia. Schizophr Res Treatment, 2011:826976.

Yesilkaya UH, Balcioglu YH (2020) Neuroimmune correlates of the nervous system involvement of COVID-19: A commentary. J Clin Neurosci, 78:449–450.

Yesilkaya UH, Sen M, Tasdemir BG (2021) A novel adverse effect of the BNT162b2 mRNA vaccine: First episode of acute mania with psychotic features. Brain Behav Immun Health, 18:100363.

Yolken RH, Torrey EF (1995) Viruses, schizophrenia, and bipolar disorder. Clin Microbiol Rev, 8:131-145.

Authors Contributions: The author(s) have declared that they have made a significant scientific contribution to the study and have assisted in the preparation or revision of the manuscript

Peer-review: Externally peer-reviewed.

Conflict of Interest: No conflict of interest was declared.

Financial Disclosure: No financial support was declared for this study.