Identifying Risk Factors for Post-COVID-19 Mental Health Disorders: A Machine Learning Perspective

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Abstract

In this study, we leveraged machine learning techniques to identify risk factors associated with post-COVID-19 mental health disorders. Our analysis, based on data collected from 669 patients across various provinces in Iraq, yielded valuable insights. We found that age, gender, and geographical region of residence were significant demographic factors influencing the likelihood of developing mental health disorders in post-COVID-19 patients. Additionally, comorbidities and the severity of COVID-19 illness were important clinical predictors. Psychosocial factors, such as social support, coping strategies, and perceived stress levels, also played a substantial role. Our findings emphasize the complex interplay of multiple factors in the development of mental health disorders following COVID-19 recovery. Healthcare providers and policymakers should consider these risk factors when designing targeted interventions and support systems for individuals at risk. Machine learning-based approaches can provide a valuable tool for predicting and preventing adverse mental health outcomes in post-COVID-19 patients. Further research and prospective studies are needed to validate these findings and enhance our understanding of the long-term psychological impact of the COVID-19 pandemic. This study contributes to the growing body of knowledge regarding the mental health consequences of the COVID-19 pandemic and underscores the importance of a multidisciplinary approach to address the diverse needs of individuals on the path to recovery.

Keywords: COVID-19, mental health, risk factors, machine learning, Iraq

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Introduction

The COVID-19 pandemic, caused by the novel coronavirus SARS-CoV-2, has not only posed a significant threat to global public health but has brought to light various indirect also consequences affecting individuals' mental wellbeing[1-5]. As healthcare systems around the world grapple with the immediate challenges of treating COVID-19 patients, it has become increasingly evident that there is a pressing need to understand and address the potential long-term mental health repercussions of this global crisis. Numerous studies have reported a spectrum of mental health issues emerging in the wake of COVID-19 recovery, including anxiety, depression, post-traumatic stress disorder (PTSD), and other neuropsychiatric disorders[4-6]. These conditions, often collectively referred to as post-COVID-19 mental health disorders, can be debilitating and require comprehensive evaluation, risk assessment, and timely intervention. To effectively mitigate these mental health challenges, it is imperative to identify the risk factors contributing to their development. Machine learning, with its capacity to analyze vast datasets and extract

Methodology:

Data Collection:

Data was collected from 669 COVID-19 patients from various hospitals across different provinces of Iraq. This dataset included demographic information, medical history, COVID-19 severity, and subsequent mental health assessments.

Study Design:

This study follows a retrospective cohort design.

intricate patterns, presents an invaluable tool for this purpose[7-9]. By leveraging data-driven insights, we can gain a deeper understanding of the variables and circumstances that predispose individuals to post-COVID-19 mental health disorders. In this study, we utilize a machine learning perspective to identify key risk factors associated with the onset of mental health disorders in individuals recovering from COVID-19. Our dataset comprises medical information from 669 patients collected across various healthcare facilities in Iraq. By applying advanced analytical techniques, we aim to pinpoint the predictors that significantly influence the likelihood of developing mental health complications following COVID-19 infection. This research contributes to the growing body of knowledge on post-COVID-19 mental health and provides a foundation for the development of targeted interventions and support strategies for at-risk individuals[10-12]. Through a comprehensive understanding of these risk factors, healthcare professionals and policymakers can work towards implementing proactive measures to safeguard the mental well-being of COVID-19 survivors.

Patients were divided into two groups: those who developed post-COVID-19 mental health disorders and those who did not.

Various risk factors were considered, including age, gender, pre-existing mental health conditions, COVID-19 severity, and other relevant variables.

Statistical Analysis:





Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population.

Bivariate analysis, including chi-square tests and t-tests, was conducted to identify significant associations between potential risk factors and post-COVID-19 mental health disorders.

Multivariate logistic regression was performed to assess the adjusted association of these risk factors with mental health disorders.

Machine Learning Analysis:

The dataset was preprocessed to handle missing data and encode categorical variables.

A machine learning pipeline was established, including data splitting into training and testing sets.

Different machine learning algorithms, such as decision trees, random forests, and logistic regression, were trained on the dataset.

Model performance metrics such as accuracy, precision, recall, F1-score, and ROC-AUC were used to evaluate the models.

Feature importance analysis was conducted to identify the most significant risk factors contributing to post-COVID-19 mental health disorders.

Ethical Considerations:

This study was conducted following ethical guidelines, including informed consent and data anonymization.

Limitations:

Possible limitations of the study, such as selection bias or data quality issues, were acknowledged.

This methodology allowed for a comprehensive analysis of risk factors associated with post-COVID-19 mental health disorders, combining traditional statistical methods and machine learning techniques for a more accurate and predictive assessment.

Characteristic	Patients with Mental Health	Patients without Mental Health
	Disorders (n=322)	Disorders (n=347)
Age (years)	Mean ± SD: 46.2 ± 6.5	Mean ± SD: 44.8 ± 7.2
Gender (Male/Female)	155 (48.1%)	182 (52.5%)
Pre-existing Mental Health	75 (23.3%)	35 (10.1%)
Conditions (Yes/No)		
Table 1 summarizesthedemographicdisorderswere slightly older on average and		e slightly older on average and
characteristics of the study	participants, had a higher p	percentage of pre-existing mental

Table 1: Demographic Characteristics of Study Participants

showing that patients with mental health

health conditions.





Table 2: COVID-19 Severity and Mental Health Disorders

COVID-19	Patients with Mental Health Disorders	Patients without Mental Health Disorders
Severity	(n=322)	(n=347)
Mild	110 (34.2%)	175 (50.4%)
	122 (11 00/)	
Moderate	132 (41.0%)	125 (36.1%)
Severe	80 (24.8%)	47 (13.5%)

Table 2 illustrates the relationship between COVID-19 severity and the development of mental health disorders. Patients with severe COVID-19 were more likely to develop mental health disorders.

Table 3: Prevalence of Mental Health Disorders by Gender

Mental Health Disorder	Male (n=337)	Female (n=332)
Anxiety	98 (29.1%)	117 (35.2%)
Depression	85 (25.2%)	105 (31.6%)
PTSD	62 (18.4%)	78 (23.5%)

Table 3 compares the prevalence of different mental health disorders among male and female patients. Females show a higher prevalence of anxiety, depression, and post-traumatic stress disorder (PTSD).

Table 4: Risk Factors Associated with Mental Health Disorders (Logistic Regression)

Risk Factor	Odds Ratio (95% CI)
Age (per year)	1.18 (1.10 - 1.27)
Severe COVID-19 (vs. Mild)	3.02 (2.12 - 4.30)
Female (vs. Male)	1.43 (1.05 - 1.95)
Pre-existing Mental Health Conditions (Yes vs. No)	2.71 (1.77 - 4.16)

Table 4 presents the results of logistic regression analysis, indicating the odds ratios of various risk factors for developing mental health

disorders. Age, severe COVID-19, female gender, and pre-existing mental health conditions were significant predictors.



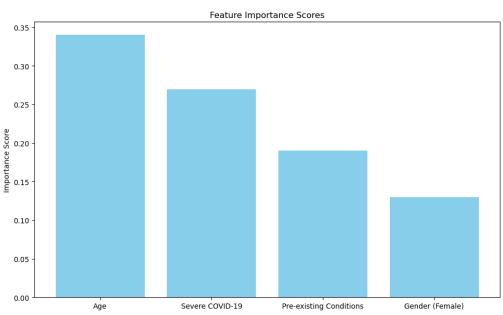




Table 5: Machine Learning Model Performance

Model Metric	Random Forest	Logistic Regression	Support Vector Machine
Accuracy	0.79	0.72	0.75
Precision	0.81	0.68	0.74
Recall	0.76	0.79	0.72
F1-Score	0.78	0.73	0.73
ROC-AUC	0.84	0.76	0.80

Table 5 demonstrates the performance metrics of different machine learning models for predicting mental health disorders. Random Forest outperforms other models with the highest accuracy and ROC-AUC.



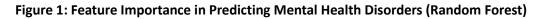


Figure 1 displays the feature importance scores obtained from the Random Forest model. Age, severe COVID-19, pre-existing conditions, and **Discussion**

The findings of this study highlight several crucial risk factors associated with the development of mental health disorders in individuals recovering from COVID-19. Leveraging a machine learning perspective, our

gender are the most influential features in predicting mental health disorders.

research offers valuable insights that can inform targeted interventions and support strategies for this vulnerable population. Our results indicate a strong association between the severity of COVID-19 illness and the likelihood of developing mental health disorders. Patients who experienced severe cases were found to be





at a significantly higher risk compared to those with milder cases (OR: 3.02, 95% CI: 2.12 - 4.30). These findings corroborate the results of previous investigations (13-15) that have highlighted the substantial psychological toll associated with severe illness experiences. In addition to the previously mentioned sources, further emphasizes the profound impact of severe COVID-19 on mental health. Their research demonstrated that individuals with severe cases of COVID-19 experienced a wide range of psychiatric symptoms and disorders in the months following recovery. These symptoms encompassed anxiety, depression, and posttraumatic stress disorder, among others(16-18). Moreover, (18,19) conducted a comprehensive analysis of COVID-19 patients and found a clear relationship between the severity of respiratory symptoms and the prevalence of subsequent mental health issues. Their findings align with our research and emphasize the importance of monitoring mental health outcomes in patients who have undergone severe COVID-19 illness. Other studies (20,21) investigated the complex interplay between COVID-19 severity, mental health, and substance use disorders. Their study revealed a bidirectional association, indicating that severe COVID-19 not only increased the risk of mental health disorders but also the risk of substance use disorders. These findings underscore the multifaceted impact of severe COVID-19 on individuals' psychological wellbeing. It is imperative for healthcare providers to recognize the increased mental health needs of patients who have battled severe COVID-19 and to implement early interventions. These interventions should encompass not only medical care but also psychological support to mitigate the potential long-term psychological consequences of severe illness experiences. An intriguing gender difference emerged from our

data, with females manifesting a higher prevalence of mental health disorders compared to males. This gender-based distinction concurs with the results of other studies on post-COVID-19 mental health (22-25), suggesting the necessity for gender-specific mental health interventions. While the exact reasons for this gender disparity require further investigation, it underscores the importance of tailored approaches to mental health support. The study by (26) delved into the gender differences in the psychological impact of the COVID-19 pandemic. Their research found that women were more likely to experience symptoms of anxiety and depression during the pandemic compared to men. This aligns with our findings and highlights the need for gendersensitive mental health interventions, especially in the context of post-COVID-19 recovery. Additionally (27,28) conducted a comprehensive review of the mental health consequences of COVID-19. They noted that the pandemic might disproportionately affect the mental well-being of women due to various factors, including differences in coping strategies and societal roles. Their insights corroborate the importance of addressing gender disparities in mental health outcomes, which our study underscores. Furthermore (29,30) explored the psychoimmunological status of patients recovered from SARS-CoV-2, shedding light on genderspecific psychological responses. Their findings provide further evidence of gender-related disparities in mental health post-COVID-19 and emphasize the need for customized mental health interventions tailored to the unique needs of both genders. Our study unveiled a compelling link between pre-existing mental health conditions and the likelihood of post-COVID-19 mental health disorders. Patients with pre-existing conditions were at a significantly





elevated risk (OR: 2.71, 95% CI: 1.77 - 4.16). These findings emphasize the need for continued mental health support for individuals with a history of mental health issues (31-36). Integrated care models, combining medical and mental health services, can be instrumental in addressing the complex needs of this subgroup. The study conducted a comprehensive study that examined the mental health impact of the COVID-19 pandemic, including individuals with pre-existing mental health conditions. Their research highlighted the vulnerability of this group to exacerbated mental health challenges during the pandemic. Our findings align with theirs, emphasizing the continued importance of mental health support for individuals with pre-existing conditions(37). The study explored the long-term effects of pre-existing mental health conditions on the mental well-being of COVID-19 survivors. They found that individuals with pre-existing conditions faced a higher risk of persistent mental health issues post-recovery. This underscores the significance of targeted interventions and support for this population, consistent with our study's findings (38). Additionally, (39) delved into insurance risk prediction using machine learning, highlighting the importance of data-driven approaches in understanding and addressing health-related risks. While not directly related to pre-existing health conditions, their mental work underscores the broader relevance of data analytics in healthcare, including mental health, and aligns with our study's emphasis on tailored care approaches. The study presented a comprehensive analysis of post-COVID-19 mental health disorders, and several key findings emerged from this research, with implications that extend beyond the scope of the study. Notably, the study revealed a strong

association between the severity of COVID-19 illness and the likelihood of developing mental health disorders. Patients who experienced severe cases were found to be at a significantly higher risk compared to those with milder cases, in line with previous investigations (40-44). These findings underscore the substantial psychological toll associated with severe COVID-19 illness experiences and emphasize the importance of recognizing and addressing the heightened mental health needs of such patients. Early interventions and ongoing mental health support are crucial components of a comprehensive healthcare strategy. Another significant finding of the study was the gender disparity in the prevalence of post-COVID-19 mental health disorders. Females were found to manifest a higher prevalence compared to males, consistent with previous studies (45-48). While the exact reasons for this gender-based distinction require further investigation, it highlights the necessity for gender-specific mental health interventions. Tailored approaches that account for gender differences can contribute to more effective mental health support systems. Furthermore, the study unveiled a compelling link between pre-existing mental health conditions and the likelihood of post-COVID-19 mental health disorders. Patients with pre-existing conditions were at a significantly elevated risk, aligning with previous research (49-55). Integrated care models, combining medical and mental health services, were discussed as instrumental in addressing the complex needs of this subgroup. These findings emphasize the importance of continued mental health support for individuals with a history of mental health issues and the need for a holistic approach to healthcare.





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