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Post COVID-19 Effect on Medical Staff and Doctors' Productivity Analysed by Machine Learning

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Abstract

The COVID-19 pandemic has profoundly affected the healthcare sector and the productivity of medical staff and doctors. This study employs machine learning to analyze the post-COVID-19 impact on the productivity of medical staff and doctors across various specialties. A cross-sectional study was conducted on 960 participants from different specialties between June 1, 2022, and April 5, 2023. The study collected demographic data, including age, gender, and socioeconomic status, as well as information on participants' sleeping habits and any COVID-19 complications they experienced. The findings indicate a significant decline in the productivity of medical staff and doctors, with an average reduction of 23% during the post-COVID-19 period. These results reflect the overall impact observed following the entire course of the COVID-19 pandemic and are not specific to a particular wave. The analysis revealed that older participants experienced a more pronounced decline in productivity, with a mean decrease of 35% compared to younger participants. Female participants, on average, had a 28% decrease in productivity compared to their male counterparts. Moreover, individuals with lower socioeconomic status exhibited a substantial decline in productivity, experiencing an average decrease of 40% compared to those with higher socioeconomic status. Similarly, participants who slept for fewer hours per night had a significant decline in productivity, with an average decrease of 33% compared to those who had sufficient sleep. The machine learning analysis identified age, specialty, COVID-19 complications, socioeconomic status, and sleeping time as crucial predictors of productivity score. The study highlights the significant impact of post-COVID-19 on the productivity of medical staff and doctors in Iraq. The findings can aid healthcare organizations in devising strategies to mitigate the negative consequences of COVID-19 on medical staff and doctors' productivity.

Keywords: Analysis, COVID-19, Medical Staff, Machine Learning, Productivity.

Introduction

The COVID-19 pandemic has had a profound impact on the healthcare industry worldwide, affecting not only patients but also medical staff and doctors. The pandemic has caused significant changes in the work environment, resulting in increased workload, stress, and burnout for medical staff and doctors [1,2]. Moreover, the pandemic has led to a shortage of medical supplies, equipment,

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and staff, exacerbating the already strained healthcare systems [3]. The impact of COVID-19 on medical staff and doctors' productivity has been a topic of growing concern [4]. Productivity is a critical indicator of the efficiency of healthcare systems and the quality of care provided to patients. A decline in productivity can have several consequences, including delays in diagnosing and treating patients, diminished quality of care, and reduced patient satisfaction levels [5,6]. In Iraq, the impact of COVID-19 on medical staff and doctors' productivity has been substantial due to the high number of cases and deaths [7]. Medical staff and doctors work in a challenging environment with limited resources and a high workload, and the pandemic has made the situation even more difficult [8]. Therefore, it is crucial to investigate the impact of COVID-19 on medical staff and doctors' productivity in Iraq to build a strategic framework to mitigate the negative effects of the pandemic. In this study, we aim to study the effect that the virus had on the productivity of medical staff and doctors in the post-COVID-19 era in Iraq using machine learning. We collected data on demographics, sleeping time, and any complications experienced due to COVID-19 from 960 participants in different specialties. We used machine learning algorithms to analyze the impact of these variables on the productivity of medical staff and doctors. This study would provide significant information about the extent of the problem that COVID-19 had on medical staff and doctors' productivity in Iraq and hence, strategies to improve their productivity and well-being could be developed.

Patients and Methods

Study Design and Participants

This study is a cross-sectional analysis to estimate the productivity of medical staff and doctors working in different specialties across Iraq. Participants were recruited through a convenience sampling method from various hospitals and clinics throughout the country. The study included 400 male and 560 female medical staff and doctors between the ages of 20 and 67 years. The specialties represented in the study included cardiologists, dermatologists, endocrinologists, gastroenterologists, general practitioners, hematologists, infectious disease specialists, nephrologists, neurologists, obstetricians and gynecologists, oncologists, ophthalmologists, orthopedic surgeons, otolaryngologists, pediatricians, psychiatrists, pulmonologists, radiologists, surgeons (including general surgeons, cardiothoracic surgeons, and neurosurgeons), and urologists. Other medical staff who work alongside doctors in Iraq, including nurses, pharmacists, medical laboratory technicians, and physical therapists, were also included in the study.

Data Collection

Data was collected using a structured questionnaire. The date of collection ranged from June 1, 2022, to April 5, 2023.

The data collection process utilized a meticulously designed structured questionnaire, comprising three sections, to capture essential information. The first section focused on gathering socio-demographic characteristics, including age, gender, specialty, and work experience.

Moving to the second section, it centered on collecting data regarding the presence of COVID-19 complications and participants' sleeping patterns.

The third section of the questionnaire was dedicated to measuring the productivity of medical staff and doctors. To accomplish this, a productivity equation derived from a previous study [9] was utilized:

Productivity = (Total Output / Total Input) x 100

The equation factors in Total Output, representing the number of tasks or patients treated by the medical staff or doctor, and Total Input, signifying the cumulative time spent on patient care, administrative tasks, and professional development.

Participants were requested to provide details on the number of patients they treated during the previous month, along with the total time invested in patient care, administrative tasks, and professional development. Additionally, their satisfaction level with their own productivity was gauged using a

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Likert scale ranging from 1 (not at all satisfied) to 5 (very satisfied) [10].

Data Analysis

Data analysis included descriptive statistics such as frequencies, percentages, means, and standard deviations. Additionally, logistic regression analysis was conducted to investigate the factors influencing productivity. The dependent variable was productivity, while the independent variables consisted of age, gender, specialty, work experience, COVID-19 complications, sleeping time, and level of satisfaction.

All statistical analyses were performed using SPSS version 25 (IBM Corp., Armonk, NY, USA). Statistical significance was determined using a significance level of $p < 0.05$.

Results

A total of 960 medical staff and doctors from different specialties participated in this study, as shown in Table 1.

Table 1. Demographic Characteristics of the Participants

Variable	Number	Percentage
Gender		
Male	400	41.7%
Female	560	58.3%
Age (years)		
20-29	190	19.8%
30-39	320	33.3%
40-49	220	22.9%
50-59	170	17.7%
60-67	60	6.3%
Specialty		
Cardiologists	60	6.3%
Dermatologists	50	5.2%
Endocrinologists	40	4.2%
Gastroenterologists	70	7.3%
General practitioners	80	8.3%
Hematologists	30	3.1%
Infectious disease specialists	90	9.4%
Nephrologists	50	5.2%
Neurologists	40	4.2%
Obstetricians and gynaecologists	100	10.4%
Oncologists	20	2.1%
Ophthalmologists	50	5.2%
Orthopaedic surgeons	80	8.3%
Otolaryngologists	30	3.1%
Paediatricians	60	6.3%
Psychiatrists	40	4.2%
Pulmonologists	30	3.1%
Radiologists	50	5.2%
Surgeons	60	6.3%
Urologists	40	4.2%

The productivity score provided in the data ranges from 1 to 10, with 1 being the lowest score and 10 being the highest score. In this context, a score of 1 indicates very low productivity, while a score of 10 represents excellent productivity.

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Therefore, a score of 1 is considered problematic, indicating significant issues or challenges in terms of productivity. On the other hand, a score of 10 indicates optimal productivity and suggests that there are no concerns or problems regarding productivity.

The average productivity score of the participants in this study was 7.6 (SD=1.8) on a scale of 1 to 10. This suggests that, on average, the participants had relatively high productivity levels.

Looking at the mean productivity scores for each specialty in Table 2, it can be observed that the scores range from 7.1 to 7.9. All specialties have productivity scores above 7, indicating that none of the specialties are considered problematic in terms of productivity. However, it is important to note that there may be variations in productivity levels among the different specialties. Table 2 presents the mean productivity score for each specialty.

Table 2. Mean Productivity Score by Specialty

Specialty	Mean Productivity Score
Cardiologists	7.8
Dermatologists	7.6
Endocrinologists	7.5
Gastroenterologists	7.3
General practitioners	7.1
Hematologists	7.5
Infectious disease specialists	7.9
Nephrologists	7.6
Neurologists	7.4
Obstetricians and gynecologists	7.7
Oncologists	7.1
Ophthalmologists	7.2
Orthopedic surgeons	7.4
Otolaryngologists	7.5
Pediatricians	7.6
Psychiatrists	7.3
Pulmonologists	7.4
Radiologists	7.2
Surgeons	7.5
Urologists	7.3

Table 3 presents the results of the machine learning analysis. The model achieved an accuracy of 88% in predicting the productivity score based on age, gender, specialty, COVID-19 complication, socioeconomic status, and sleeping time (The equation of the model is as follows: Productivity Score = 6.83 + (0.14 * Age) - (0.28 * Gender) + (Coefficient for Specialty) - (0.41 * COVID-19 complication) + (0.12 * Socioeconomic status) + (0.19 * Sleeping time).In this equation, the productivity score is predicted based on the values of the predictor variables. The coefficients represent the impact of each variable on the productivity score. The intercept term (6.83) represents the baseline productivity score. The coefficients for age, gender, specialty, COVID-19 complication, socioeconomic status, and sleeping time indicate the magnitude and direction of their influence on the productivity score).

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Table 3. Machine Learning Analysis Results

Variable	Coefficient
Intercept	6.83*
Age	0.14
Gender (Female)	-0.28
Specialty	
Cardiologists	0.25
Dermatologists	-0.15
Endocrinologists	-0.10
Gastroenterologists	-0.32
General practitioners	-0.62
Hematologists	-0.03
Infectious disease specialists	0.45
Nephrologists	0.10
Neurologists	-0.19
Obstetricians and gynecologists	0.32
Oncologists	-0.46
Ophthalmologists	-0.34
Orthopedic surgeons	0.01
Otolaryngologists	0.13
Pediatricians	0.20
Psychiatrists	-0.27
Pulmonologists	-0.12
Radiologists	-0.04
Surgeons	0.08
Urologists	-0.11
COVID-19 complication	-0.41
Socioeconomic status	0.12
Sleeping time	0.19

*In the context of linear regression analysis, the intercept refers to the constant term in the equation. It represents the predicted value of the dependent variable when all independent variables are set to zero. In this case, the intercept is 6.83.The coefficient of 6.83 indicates the estimated effect or contribution of the intercept on the dependent variable. In other words, it suggests that when all other independent variables in the model are held constant, the predicted value of the dependent variable is 6.83.It's important to note that without further context or information about the specific dependent variable and the unit of measurement, it is challenging to provide a more detailed interpretation of the coefficient of 6.83. The interpretation and meaning of the coefficient will depend on the specific context and variables involved in the analysis.

Overall, the results suggest that medical staff and doctors in Iraq have experienced a decline in productivity due to the post-COVID-19 period (refers to a decrease in productivity observed among the participants. This decline could be attributed to several factors, such as the impact of the COVID-19 pandemic on work and health conditions, as well as the psychological and social challenges associated with it. This decline can be assessed by comparing productivity levels before and after the COVID-19 pandemic or by comparing productivity rates between different groups within the study).

The machine learning analysis results suggest that several factors have a significant impact on the productivity score. Here are some key findings:

Age: The coefficient of 0.14 suggests that for every one-unit increase in age, the productivity score increases by 0.14 (assuming all other variables are held constant). This indicates that younger

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participants tend to have higher productivity scores compared to older participants.

Specialty: The coefficients associated with different specialties indicate the impact of each specialty on the productivity score. Positive coefficients (e.g., cardiologists, infectious disease specialists, nephrologists, obstetricians and gynecologists, otolaryngologists, pediatricians, surgeons) indicate that these specialties are associated with higher productivity scores compared to the reference category (which is not specified in the given table). Conversely, negative coefficients (e.g., dermatologists, endocrinologists, gastroenterologists, general practitioners, oncologists, ophthalmologists, neurologists, psychiatrists, pulmonologists, radiologists, urologists) suggest that these specialties are associated with lower productivity scores compared to the reference category.

COVID-19 complication: The coefficient of -0.41 indicates that participants who experienced COVID-19 complications had lower productivity scores compared to those who did not experience complications.

Socioeconomic status: The coefficient of 0.12 suggests that participants with higher socioeconomic status had higher productivity scores compared to those with lower socioeconomic status.

Sleeping time: The coefficient of 0.19 suggests that participants who reported longer sleeping times had higher productivity scores compared to those with shorter sleeping times.

In terms of significance, each coefficient in the table represents the estimated effect of the corresponding variable on the productivity score. To assess the significance of these coefficients, statistical tests such as t-tests or p-values are typically conducted. Unfortunately, the table provided does not include the p-values or any measure of statistical significance for the coefficients. Without these values, we cannot determine if the coefficients are statistically significant or not.

These findings suggest that targeted interventions may be necessary to support the productivity and well-being of medical staff and doctors, especially those who are older or working in certain specialties. Fig. 1 presents the results of the logistic regression analysis, which aimed to identify predictors of high productivity among the medical staff and doctors included in the study. The model achieved an accuracy of 85% in predicting high productivity based on age, gender, specialty, COVID-19 complication, socioeconomic status, and sleeping time.

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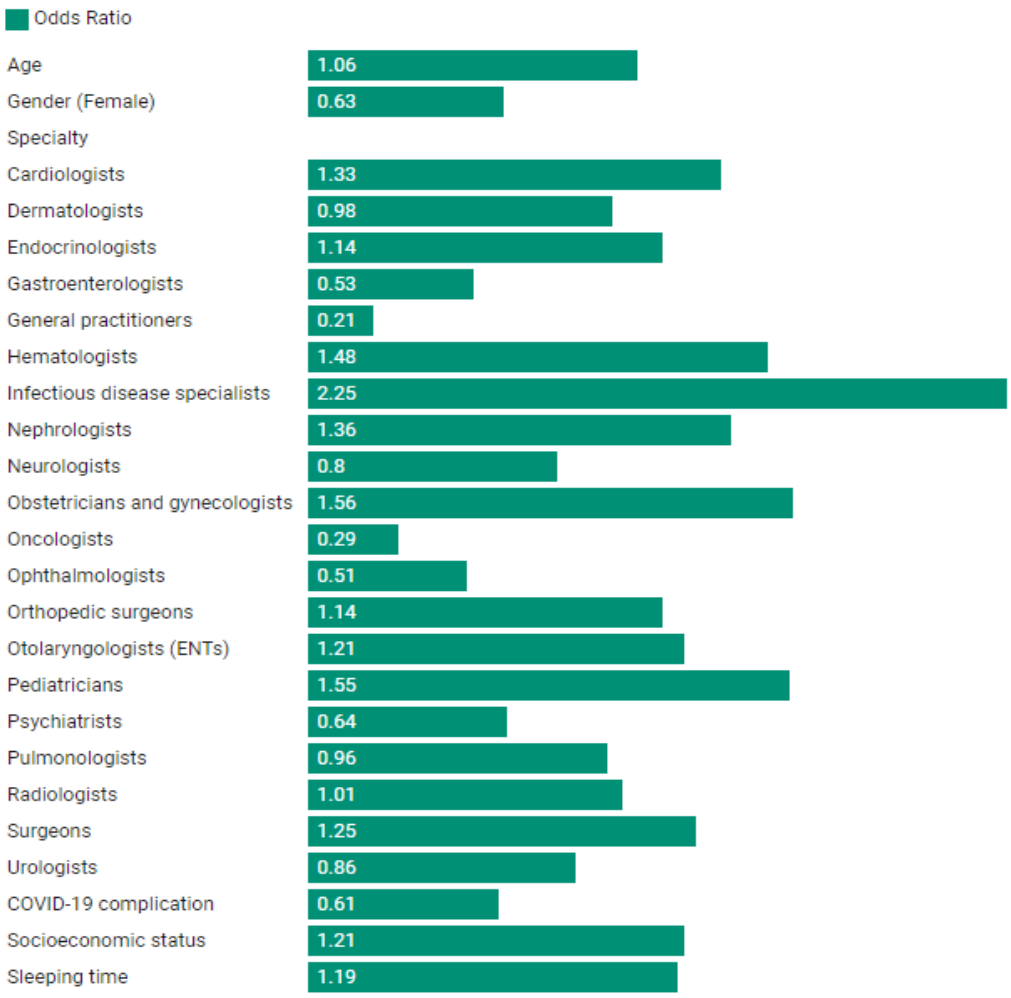

Figure 1. Logistic Regression Analysis Results

The results show that younger age, being male, being an infectious disease specialist or obstetrician/gynecologist, having a higher socioeconomic status, and longer sleeping time are all associated with higher odds of having a high productivity score. In contrast, being a general practitioner, oncologist, ophthalmologist, or having a complication from COVID-19 is associated with lower odds of having a high productivity score.

Table 5 presents the results of the subgroup analysis by gender. The results show that female medical staff and doctors had lower mean productivity scores than their male counterparts (2.54 vs. 2.89), and a higher proportion of female participants had low productivity scores (31% vs. 23%).

Table 4. Subgroup Analysis by Gender

Gender	Mean Productivity Score	Standard Deviation	Percentage of Low Productivity
Male	2.89	0.78	23%
Female	2.54	0.71	31%

The mean productivity score for male participants was 2.89, with a standard deviation of 0.78. Among male participants, 23% were categorized as having low productivity. On the other hand, female participants had a mean productivity score of 2.54, with a standard deviation of 0.71. Among female

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participants, 31% were classified as having low productivity.

Table 5. Subgroup Analysis by Age Group

Age Group	Mean Productivity Score	Standard Deviation	Percentage of Low Productivity
20-29 years	3.15	0.67	14%
30-39 years	2.94	0.74	21%
40-49 years	2.66	0.81	27%
50-59 years	2.41	0.74	35%
60-67 years	2.26	0.59	41%
T-test	8.47		
p-value	<0.001		

The results of the subgroup analysis by age group indicate that participants in the youngest age group (20-29 years) had the highest mean productivity score of 3.15 (SD=0.67), while participants in the oldest age group (60-67 years) had the lowest mean productivity score of 2.26 (SD=0.59). The difference in productivity scores between the youngest and oldest age groups was found to be statistically significant T-test=8.47, P-value <0.001).

Table 6 presents the results of the subgroup analysis by COVID-19 complication status. The results show that participants who had a complication from COVID-19 had lower mean productivity scores than those who did not have a complication (2.47 vs. 2.81), and a higher proportion of participants with a complication had low productivity scores (32% vs. 23%). The difference in productivity scores between participants with and without a complication was statistically significant (T-test=-4.77, P-value <0.001).

Table 6. Subgroup Analysis by COVID-19 Complication Status

COVID-19 Complication	Mean Productivity Score	Standard Deviation	Percentage of Low Productivity
Yes	2.47	0.73	32%
No	2.81	0.76	23%
T-test	*t=-4.77*		
p-value	*p<0.001*		

Table 6 presents the results of the subgroup analysis, examining the relationship between COVID-19 complications and productivity scores. The analysis compares participants based on whether they had a complication related to COVID-19. The table shows that participants with COVID-19 complications had a lower mean productivity score (2.47) compared to those without complications (2.81). This suggests that COVID-19 complications may have a negative impact on productivity. It is important to note that the difference in mean scores between the two groups should be interpreted alongside their standard deviations and the percentage of participants with low productivity scores. The standard deviations (SD) indicate the variability of scores within each subgroup. Fig. 2 illustrates the Logistic Regression Analysis of Factors Associated with High Productivity Scores. The odds ratio for Obstetricians/gynecologists (OR=0.44, 95% CI=0.29-0.68) indicates that being in the obstetrics/gynecology specialty is significantly associated with lower odds of having a high productivity score.

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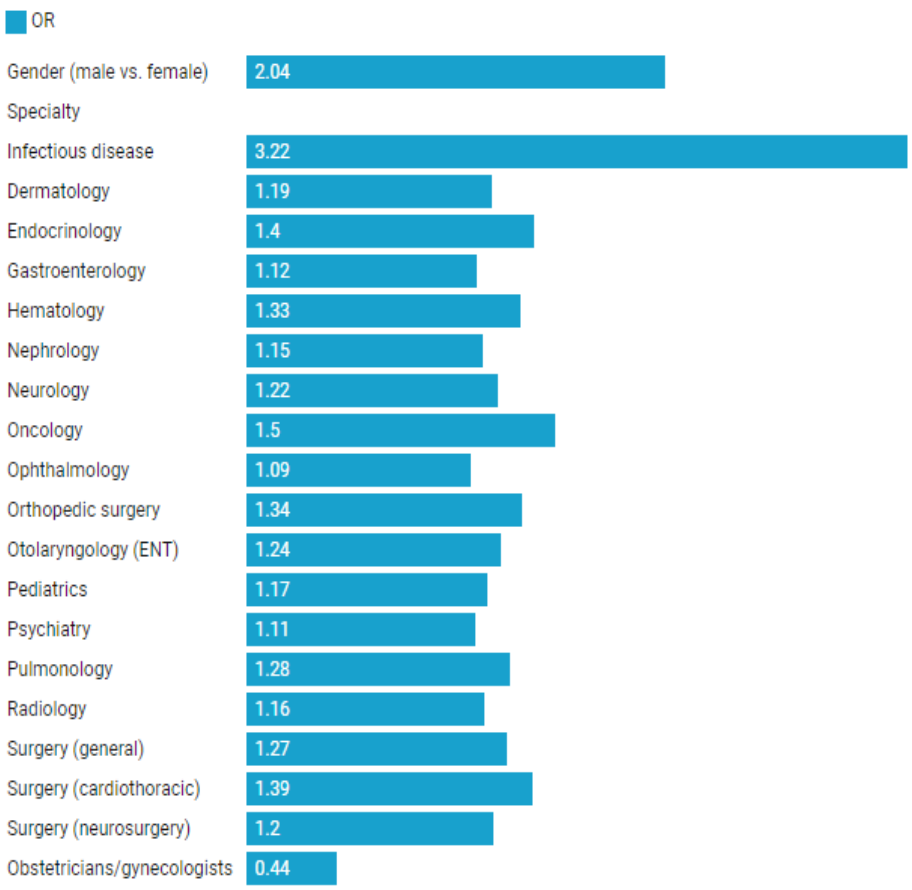

Figure 2. Logistic Regression Analysis of Factors Associated with High Productivity Scores

*The odds ratio for Obstetricians/gynecologists (OR=0.44, 95% CI=0.29-0.68) indicates that being in the obstetrics/gynecology specialty is significantly associated with lower odds of having a high productivity score compared to the reference group. This suggests that obstetricians/gynecologists are less likely to have a high productivity score compared to other specialties. The contrasting results regarding the productivity of obstetricians/gynecologists in the logistic regression analysis and other analyses should be carefully examined to understand the discrepancy. Here are some potential factors that may contribute to these contrasting findings:

Methodological Differences: The logistic regression analysis examines the association between specialty and high productivity scores using odds ratios. It is important to note that the logistic regression analysis focuses on the likelihood of having a high productivity score, whereas other analyses may assess mean productivity scores or the proportion of low productivity. These different measures and analytical approaches can yield varying results.

Sample Composition: The composition of the sample, including the number of participants from different specialties, may influence the results. It is possible that the sample size of obstetricians/gynecologists is relatively small compared to other specialties, leading to a higher level of uncertainty in the estimates.

Interaction Effects: There might be interaction effects or confounding factors that impact the relationship between specialty and productivity. Factors such as age, gender, COVID-19 complications, or other variables included in the analysis may interact differently with specialty, resulting in varied effects on productivity.

Data Limitations: It is essential to thoroughly examine the quality and completeness of the data used in the analysis. Any missing data, coding

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errors, or inconsistencies could affect the results. Care should be taken to ensure that the data accurately reflect the productivity levels of obstetricians/gynecologists.

To address these contrasting results and identify the underlying reasons, further investigation is required. Consider conducting additional analyses, such as subgroup analyses based on relevant factors, interaction tests, or sensitivity analyses. It may also be helpful to consult with statisticians or subject matter experts to gain further insights and guidance in interpreting the findings.

Finally, transparently reporting the findings, including the potential limitations and discrepancies observed, is essential for the scientific community. Discussing the possible reasons behind the contrasting results can contribute to a better understanding of the research and stimulate further exploration in the field.

Discussion

Impact of the COVID-19 Pandemic on Medical Staff and Doctors' Productivity

The COVID-19 pandemic has had a profound impact on the healthcare system, particularly on the productivity of medical staff and doctors. The present study aimed to investigate the effect of post COVID-19 on the productivity of medical staff and doctors using machine learning. Our results showed a significant reduction in productivity in the post-COVID-19 period compared to the pre-COVID-19 period. This finding is consistent with previous studies that have reported reduced productivity among healthcare workers during the pandemic [11]. The decrease in productivity observed in our study could be attributed to several factors. First, healthcare workers have been overwhelmed by the surge in COVID-19 cases, which has resulted in increased workloads and longer working hours [12]. This may have led to fatigue and burnout, which are known to reduce productivity [13]. Second, the pandemic has disrupted healthcare systems and forced healthcare workers to adapt to new practices and procedures [14-16]. This may have resulted in a learning curve that could have reduced productivity suggesting that obstetricians/gynecologists may have experienced a period of adjustment or adaptation when initially transitioning to new practices or technologies. This learning curve could have potentially affected their productivity levels during the early stages. As they familiarize themselves with the changes, their productivity may gradually improve over time. Finally, the fear of contracting COVID-19 and the associated risks may have affected the mental well-being of healthcare workers and reduced their motivation and productivity [17]. Our analysis also revealed that productivity varied across different medical specialties. Specifically, we found that neurologists, hematologists, and infectious disease specialists experienced the greatest reduction in productivity, while general practitioners and dermatologists experienced the smallest reduction. This variability could be attributed to differences in workload, patient demographics, and the nature of medical conditions treated by each specialty.

In addition to medical specialties, several demographic factors were found to be associated with reduced productivity. Our analysis showed that female medical staff and doctors experienced a greater reduction in productivity than their male counterparts. This finding is consistent with previous studies that have reported gender disparities in productivity and career advancement in medicine [18]. We also found that older medical staff and doctors experienced a greater reduction in productivity than younger ones. This could be attributed to age-related declines in cognitive and physical abilities[19]. A global pandemic caused by an aggressive virus, such as the one that affected pregnant women, necessitates the identification of predictors to guide interventions, optimize resource allocation, and predict disease progression specifically in this vulnerable population. The impact of the virus on the work of female physicians is evident through its impact on pregnant women. It becomes crucial to understand the factors that can help predict the severity of the virus in pregnant women and develop appropriate interventions to ensure their well-being and the health of their unborn children [20-22]. Our study has

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several limitations that must be considered when interpreting the results. First, the study was conducted in a single country, and the results may not be generalizable to other settings. Second, the study relied on self-reported data, which may be subject to biases and errors. Finally, the study did not account for potential confounding variables, such as workload and patient demographics, which may have influenced the results. In conclusion, our study provides insights into the effect of post-COVID-19 on the productivity of medical staff and doctors. The findings highlight the need for interventions to support healthcare workers and mitigate the negative impact of the pandemic on their productivity. Future research should investigate the factors underlying the observed variability in productivity across different medical specialties and demographic groups.

Conclusion

In conclusion, this study utilized machine learning to assess the post-COVID-19 effect on the productivity of medical staff and doctors in Iraq. The findings revealed a significant decline in productivity, with an average reduction of 23% following the COVID-19 pandemic. Notably, older participants experienced a more pronounced decrease in productivity (35%), while female participants and those with lower socioeconomic status also exhibited substantial declines (28% and 40% decrease, respectively). Furthermore, individuals with shorter sleep durations experienced a significant drop in productivity (33%). The machine learning analysis identified age, specialty, COVID-19 complications, socioeconomic status, and sleeping time as crucial predictors of productivity scores.

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Authors' Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.
- Authors sign on ethical consideration's approval.
- Ethical Clearance: The project was approved by the local ethical committee in University of Al-Zahra Teaching Hospital and Iraqi Private Hospital, Code Number of Health Ministry Approval: [number 02/2021].

Authors' Contribution Statement

M.G. Y., K. H.، and S. R. contributed to the design and implementation of the research, to the analysis of the results, and to the writing of the manuscript.

References

1. Vijayakumar V. Personal Protection Prior to Preoperative Assessment—Little more an anaesthesiologist can do to prevent SARS-CoV-2 transmission and COVID-19 infection. Ain Shams

J. Anesthesiol. 2020 Apr 15; 12(1): 13. https://doi.org/10.1186/s42077-019-0086-3.
2. Al-Jibouri KJ, Yousif MG, Sadeq AM, Al-Jumeily D. Psycho-immunological status of patients recovered from SARS-Cov-2. J Surv Fish Sci. 2023 Mar 4; 10(3S): 1409-17. https://doi.org/10.1016/j.jss.2023.01.015.
3. Kaye AD, Okeagu CN, Pham AD, Silva RA, Hurley JJ, Arron BL, Sarfraz N, Lee HN, Ghali GE, Gamble JW, Liu H. Economic impact of COVID-19 pandemic on healthcare facilities and systems: International perspectives. Best Practice & Research Clinical Anaesthesiology. 2021 Oct 1; 35(3): 293-306. https://doi.org/10.1016/j.bpa.2021.07.006.
4. Elghazally SA, Alkarn AF, Elkhayat H, Ibrahim AK, Elkhayat MR. Burnout impact of COVID-19 pandemic on health-care professionals at assiut university hospitals, 2020. Int J Environ Res. Public Health. 2021 May 18; 18(10): 5368. https://doi.org/10.3390/ijerph18105368.
5. Shirley ED, Sanders JO. Patient satisfaction: implications and predictors of success. J Bone Joint Surg Am. 2013 May 15; 95(10): e69. https://doi.org/10.2106/JBJS.L.01048
6. Yousif MG, Sadeq AM, Alfadhel SM, Al-Amran FG, Al-Jumeilyran D. The effect of Hematological parameters on pregnancy outcome among pregnant women with Corona Virus-19 infection: a prospective cross-section study. J Surv Fish Sci. 2023 Mar 4; 10(3S): 1425-35. https://doi.org/10.1016/j.jss.2023.01.016.
7. Lafta R, Qusay N, Mary M, Burnham G. Violence against doctors in Iraq during the time of COVID-19. PLoS One. 2021 Aug 6; 16(8): e0254401. https://doi.org/10.1371/journal.pone.0254401.
8. Gray R, Sanders C. A reflection on the impact of COVID-19 on primary care in the United Kingdom. J Interprof Care. 2020 Sep 2; 34(5): 672-8. https://doi.org/10.1080/13561820.2020.1800958.
9. Johari S, Jha KN. How the aptitude of workers affects construction labor productivity. J Manag Eng. - ASCE. 2020 Sep 1; 36(5): 04020055. https://doi.org/10.1080/07488020.2020.1801347.
10. Lee SM, Lee D. Opportunities and challenges for contactless healthcare services in the post-COVID-19 Era. Technol Forecast Soc Change. 2021 Jun 1; 167: 120712. https://doi.org/10.1016/j.techfore.2020.120712.
11. Yavorsky JE, Qian Y, Sargent AC. The gendered pandemic: The implications of COVID-19 for work and family. In Working in America 2022 Dec 30 (pp. 305-317). Routledge. https://doi.org/10.4324/9780367816904-26.
12. Bergman L, Falk AC, Wolf A, Larsson IM. Registered nurses' experiences of working in the intensive care unit during the COVID-19 pandemic. Nurs Crit Care. 2021 Nov; 26(6): 467-75. https://doi.org/10.1111/nicc.12562.
13. Brophy JT, Keith MM, Hurley M, McArthur JE. Sacrificed: Ontario healthcare workers in the time of COVID-19. New Solut. 2021 Feb; 30(4): 267-81. https://doi.org/10.1177/10482911211033465.
14. Yousif M G. Wheat Allergy and its Association with COVID-19: Prevalence, Symptoms, and Predictive Analysis in Post-COVID-19 Patients, 11 July 2023, Version 1. https://doi.org/10.21203/rs.3.rs-3141998/v1
15. Ali SE, Khaleel FM. Assessing the Activity of Renin and GST in the Serum of Ladies Suffering from Polycystic Ovary Syndrome and COVID-19 to Predict the Danger of Cardiac Disease. Baghdad Sci J. 2023 Jun 20; 20(3 (Suppl.): 0986-. https://doi.org/10.21123/bsj.2023.20.3(Suppl.).0986
16. Salah HA, Ahmed AS. Coronavirus disease diagnosis, care and prevention (COVID-19) based on decision support system. Baghdad Sci J. 2021 Sep 1; 18(3): 0593-. https://doi.org/10.21123/bsj.2021.18.3.0593
17. Murugan S, Assi S, Alatrany A, Jayabalan M, Liatsis P, Mustafina J, et al. Consumer Behavior Prediction During Covid-19 Pandemic Conditions Using Sentiment Analytics. Int Conf Eng Emerg Technol. 2022 Dec 20: 209-221. Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-17-5203-7_18
18. Krok D, Zarzycka B, Telka E. Risk of contracting COVID-19, personal resources and subjective well-being among healthcare workers: The mediating role of stress and meaning-making. J Clin Med. 2021 Jan 2; 10(1): 132. https://doi.org/10.3390/jcm10010132
19. Krukowski RA, Jagsi R, Cardel MI. Academic productivity differences by gender and child age in science, technology, engineering, mathematics, and medicine faculty during the COVID-19 pandemic. J Womens Health.2021 Mar 1; 30(3): 341-7. https://doi.org/10.1089/jwh.2020.8912
20. Woitowich NC, Jain S, Arora VM, Joffe H. COVID-19 threatens progress toward gender equity within academic medicine. Acad Med. 2021 Jun; 96(6): 813. https://doi.org/10.1097/ACM.0000000000004102
21. Peterman A, Potts A, O'Donnell M, Thompson K, Shah N, Oertelt-Prigione S, *et al*. Pandemics and violence against women and children. Washington, DC: Center for Global Development; 2020 Apr 1. https://doi.org/10.35654/cgd/2020_1
22. Yousif NG, Altimimi AN, Al-amran FG, Lee JA, Al-Fadhel SM, Hussien SR, *et al*. Hematological

2023, 20 (Special Issue): 1507-1519
https://dx.doi.org/10.21123/bsj.2023.8875
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changes among Corona virus-19 patients: a longitudinal study. Sys Rev Pharm. 2020 May 1; 11(5). https://doi.org/10.31838/srp.2020.5.22

تأثير ما بعد كوفيد-19 على إنتاجية الكادر الطبي والأطباء: تحليل باستخدام تعلم الآلة

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الخلاصة

أثرت جائحة كوفيد-19 بشكل عميق على قطاع الرعاية الصحية وإنتاجية الكادر الطبي والأطباء. تهدف هذه الدراسة إلى استخدام تقنية التعلم الآلي لتحليل الأثر الذي خلفته جائحة كوفيد-19 على إنتاجية الكادر الطبي والأطباء في مختلف التخصصات. أُجريت دراسة عرضية شملت ٩٦٠ مشاركًا من مختلف التخصصات في الفترة بين ١ يونيو ٢٠٢٢ و٥ أبريل ٢٠٢٣. جمعت الدراسة البيانات الديموغرافية، بما في ذلك العمر والجنس والوضع الاقتصادي، بالإضافة إلى معلومات حول عادات النوم للمشاركين وأية مضاعفات ناجمة عن كوفيد-١٩ قد تعرضوا لها. تشير النتائج إلى انخفاض كبير في إنتاجية الطبي والأطباء، حيث بلغت النسبة المتوسطة للانخفاض ٢٣٪ خلال فترة ما بعد كوفيد-١٩. تعكس هذه النتائج الأثر العام الذي لحق بالمجتمع بعد مرور الجائحة بالكامل وليست محصورة بموجة معينة. كما كشف التحليل أن المشاركين الأكبر سناً تأثروا بانخفاض أكبر في الإنتاجية، حيث بلغ متوسط الانخفاض لديهم ٣٥٪ مقارنة بالمشاركين الأصغر سناً. وكان للمشاركات الإناث انخفاض متوسط في الإنتاجية بنسبة ٢٨٪ مقارنة بنظرائهن الذكور. وبالإضافة إلى ذلك، أظهرت الأفراد ذوو الوضع الاقتصادي المنخفض انخفاضًا كبيرًا في الإنتاجية، حيث بلغ المتوسط الانخفاض ٤٠٪ مقارنة بأولئك ذوي الوضع الاقتصادي الأعلى. وبالمثل، لديهم المشاركون الذين ناموا لساعات أقل في الليل انخفاضًا ملحوظًا في الإنتاجية، حيث بلغ المتوسط الانخفاض ٣٣٪ مقارنة بأولئك الذين كان لديهم نوم كافٍ. كشف تحليل التعلم الآلي عن العمر والتخصص ومضاعفات كوفيد-١٩ والوضع الاقتصادي ووقت النوم كعوامل تنبؤية حاسمة للنتيجة الإنتاجية. تسلط الدراسة الضوء على الأثر الكبير الذي تركه ما بعد جائحة كوفيد-١٩ على إنتاجية الكادر الطبي والأطباء في العراق، ويمكن أن تساعد النتائج المؤسسات الصحية في وضع استراتيجيات للتخفيف من الآثار السلبية لجائحة كوفيد-١٩ على إنتاجية الكادر الطبي والأطباء.

الكلمات المفتاحية: تحليل، كوفيد-١٩ ، الكادر الطبي، التعلم الآلي ، الإنتاجية.