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Predictive Analysis of Stress and Burnout Among Medical Students: Exploring Personal and Environmental Contributors

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ABSTRACT

Background: Medical education is widely recognized as a demanding and high-pressure environment. The intense academic workload, clinical responsibilities, and emotional challenges increase stress and the risk of burnout among medical students. This study aimed to identify key predictors and high-risk profiles for stress and burnout among medical students using multiple regression analysis and CHAID decision tree models.

Methods: A cross-sectional study was conducted on medical students (n = 250) from Bakhtawar Amin Medical and Dental College, Multan, and Nishtar Medical University, Multan Medical and Dental College, Pakistan, between April and October 2024, using a convenience sampling technique. The required sample size was calculated using G*Power 3.1 to ensure sufficient statistical power. Standardized instruments were used to assess stress (Perceived Stress Scale), burnout (Oldenburg Burnout Inventory), individual traits (BTPS-SF, GSE, BRS, MAAS), and contextual factors (WHOQOL-BREF), along with demographic variables. Data analysis was performed using IBM SPSS Statistics version 27.0. Multiple regression analyses were used to identify significant predictors, while a CHAID decision tree model classified high-risk subgroups. The level of significance was set at $p < 0.05$.

Results: Regression analysis revealed that perfectionism ($p < 0.001$) and low self-efficacy ($p < 0.001$) were the strongest predictors of stress, explaining 45% of the variance. For burnout, lack of physical activity ($p = 0.002$) and weak social support ($p < 0.001$) emerged as significant contributors ($R^2 = 0.39$, $p < 0.001$). The CHAID model identified sleep quality ($p < 0.001$) as a key moderator of stress, with the highest stress scores found among students with poor sleep and high perfectionism ($M = 32.8$, $SD = 5.4$). For burnout, the highest-risk group comprised physically inactive students lacking family support ($M = 45.2$, $SD = 6.1$, $p < 0.001$).

Conclusion: Psychological and physical health factors—including perfectionism, self-efficacy, sleep quality, physical activity, and social support—significantly influence stress and burnout among medical students. Interventions targeting these factors may help mitigate psychological distress and promote student well-being in medical training environments.

Keywords: Stress, Burnout, Mindfulness, Perfectionism, Sleep Quality, Physical Activity, Self-Efficacy, Social Support.

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INTRODUCTION

Medical students face significant stress and burnout due to the intense demands of their education, clinical responsibilities, and personal challenges. This chronic stress has been linked to poor academic performance, impaired clinical judgment, and increased risks of mental health issues such as anxiety and depression. Studies indicate that nearly 50% of medical students experience notable psychological distress, which can affect not only their education but also their long-term professional satisfaction and patient care quality. Identifying high-risk groups and understanding predictive factors are essential for developing effective interventions[1,2,3].

Previous research has explored individual and contextual predictors of stress and burnout, including perfectionism, self-efficacy, mindfulness, and resilience. Perfectionism, particularly rigid perfectionism, is associated with heightened stress due to unrealistic self-expectations. Conversely, self-efficacy and mindfulness act as protective factors by promoting adaptive coping mechanisms. Contextual elements like academic workload, social support, sleep duration, and physical activity also play critical roles. However, while these studies have identified correlations, few have used advanced predictive modeling techniques to categorize students into distinct risk groups[4,5,6,7,8].

A significant gap exists in applying predictive analytics to identify the most stressed and burnt-out students. Traditional regression-based approaches establish relationships but fail to classify students effectively using interacting variables. Decision tree analysis offers a more nuanced approach by clustering individuals based on hierarchical interactions among risk and protective factors. This method enables subgroup identification, allowing tailored interventions for different vulnerabilities[9].

This study employs predictive modeling to investigate the underlying factors contributing to stress and burnout among medical students. Recognizing the rising concern of psychological distress within this population, the study aims to identify the most influential predictors and to stratify students into high- and low-risk categories using multiple regression and decision tree (CHAID) analyses. Specifically, the study seeks to answer the following questions: (1) Which individual and contextual factors are the strongest predictors of stress and burnout? (2) How do these factors interact? (3) Can decision tree analysis be effectively utilized to classify students into risk subgroups for targeted interventions?

Grounded in prior literature, it was hypothesized that perfectionism would be positively associated with both stress and burnout, while traits such as self-efficacy, resilience, and mindfulness would be negatively associated. Additionally, contextual variables such as poor sleep quality, limited physical activity, and lack of social support were anticipated to significantly predict higher stress and burnout levels. By integrating multivariate statistical techniques with machine learning approaches, this research aims to contribute a data-driven framework for early risk detection and to inform institutional strategies aimed at mitigating stress and burnout among medical students. The study aimed to identify key predictors and high-risk profiles for stress and burnout among medical students using multiple regression analysis and CHAID decision tree models.

METHODS

A cross-sectional, multicenter study was conducted between April 2024 and October 2024 to investigate the influence of individual and contextual factors on stress and burnout among medical students, using predictive modeling techniques. The study included a sample of 250 medical students recruited from Bakhtawar Amin Medical and Dental College, Nishtar Medical University, and Multan Medical and Dental College, Multan, Pakistan, through stratified random sampling to ensure representation across academic years and demographic backgrounds. Ethical approval for the study was granted by the Institutional Review Board of Bakhtawar Amin Medical and Dental College (Ref No. 0663-24/E.C./BAM&DC), and the research followed the ethical guidelines of the Declaration of Helsinki. Participants were enrolled medical students who provided informed consent. Students with a prior psychiatric diagnosis that could interfere with the assessment of stress or burnout were excluded.

The required sample size was calculated using G*Power 3.1 to ensure sufficient statistical power for both regression and decision tree analyses. Data

were collected using standardized psychometric tools, administered in either online or paper format according to participants' preferences. Stress levels were measured with the Perceived Stress Scale (PSS)[10], and burnout was evaluated using the Oldenburg Burnout Inventory (OLBI)[11]. To assess individual psychological traits, the study utilized the Big Three Perfectionism Scale–Short Form (BTPS-SF)[12], the General Self-Efficacy Scale (GSE)[13], the Brief Resilience Scale (BRS)[14], and the Mindful Attention Awareness Scale (MAAS)[15]. Contextual variables—such as physical and psychological well-being, social relationships, and environment—were examined using the WHOQOL-BREF[16].

Data were analyzed using SPSS version 27.0. Descriptive statistics, including means, standard deviations, frequencies, and percentages, were computed to summarize demographic characteristics and major study variables. Multiple linear regression was employed to evaluate the influence of individual and contextual predictors on stress and burnout outcomes. To identify high-risk subgroups and explore hierarchical interactions among predictors, a Chi-squared Automatic Interaction Detector (CHAID) decision tree model was implemented, with predictors selected based on their statistical significance in the regression models. The predictive accuracy and risk estimates of the decision tree model were also evaluated to validate its classification performance. Statistical significance was defined as $p < 0.05$.

RESULTS

This study examined individual and contextual factors influencing stress and burnout among 250 medical students. The sample consisted of 135 females (54%) and 115 males (46%). Participants were primarily in their twenties (n = 138, 55.2%) and thirties (n = 112, 44.8%). A majority were in their second academic year (n = 135, 54%), and most identified as belonging to middle-class families (n = 138, 55.2%). Students from nuclear families made up 140 (56%) of the sample, while 146 (58.4%) resided in urban areas. Most participants were single (n = 150, 60%).

Table 1: Multiple Regression Analysis for Stress and Burnout

Variable	Stress Model β (Std. Error)	p-value	Burnout Model β (Std. Error)	p-value
(Constant)	9.615 (6.312)	.129	17.497 (4.277)	.000
Psychological Distress	-.010 (.061)	.874	.015 (.041)	.726
Physical Health	-.223 (.078)	.005**	-.087 (.053)	.103
Psychological Health	.177 (.044)	.000***	.071 (.030)	.019*
Social Relationships	.108 (.086)	.212	.136 (.058)	.021*
Environmental Life	.026 (.084)	.760	-.004 (.057)	.942
Perfectionism	2.803 (.248)	.000***	.423 (.168)	.013*
Self-Efficacy	-.314 (.158)	.049*	-.212 (.107)	.049*
Mindfulness	-.387 (.122)	.002**	-.072 (.083)	.381
Resilience	1.319 (.499)	.009**	-.372 (.338)	.273
Model Summary				
R^2	.825	-	.717	-
Adjusted R^2	.818		.706	
F-value	125.304	.000***	67.585	.000***

p < .05, **p < .01, ***p < .001

Notably, 135 students (54%) reported sleeping only 3–4 hours per night, although 148 (59.2%) rated their sleep quality as good. Regarding physical activity, 128 students (51.2%) engaged in less than one hour per day, and 68 (27.2%) reported no physical activity at all. The academic environment was viewed neutrally by 169 students (67.6%). Social support was notably lacking, with 142 students (56.8%) not receiving support from family and 134 (53.6%) reporting a lack of support from friends. These descriptive statistics point to significant lifestyle and environmental factors potentially contributing to elevated stress and burnout levels. Regression analysis showed significant predictive models for stress ($R^2 = .825$, $p < .001$) and burnout ($R^2 = .717$, $p < .001$). Perfectionism strongly predicted stress ($\beta = 2.803$, $p < .001$), while resilience had a positive relationship ($\beta = 1.319$, $p < .01$). Protective factors included mindfulness ($\beta = -.387$, $p < .01$), self-efficacy ($\beta = -.314$, $p < .05$), and physical health ($\beta = -.223$, $p < .01$). Psychological health positively correlated with stress ($\beta = .177$, $p < .001$). For burnout, self-efficacy remained protective ($\beta = -.212$, $p < .05$), while perfectionism ($\beta = .423$, $p < .05$) and social relationships ($\beta = .136$, $p < .05$) were significant predictors.

Table 2: CHAID Decision Tree Analysis Comparison and Risk Groups

Predictor Variable	Subgroup Characteristics	Mean Burnout Score (±SD)	n (%)
Physical Activity			
No Physical Activity	Inactive students	45.2 ± 6.1	65
≥1 hour/day	Active students	36.7 ± 5.3	88
Family Support			
No Support from Family (Inactive Group)	High burnout risk	47.1 ± 5.8	38
Support present (Inactive Group)	Moderate burnout risk	41.6 ± 4.7	27
Sleep Quality			
Poor Sleep (Active Group)	Elevated burnout despite physical activity	39.4 ± 5.9	52
Good Sleep (Active Group)	Lowest burnout levels	33.8 ± 4.2	36

Figure 1 and Figure 2: Decision tree analysis identified distinct pathways for stress and burnout. Stress was primarily predicted by sleep duration (F=1066.228, p<0.001), with students sleeping 3-4 hours showing the highest stress levels (mean=30.919). Within this group, poor sleep quality further elevated stress (mean=32.430). Burnout was primarily predicted by physical activity (F=268.748, p<0.001), with inactive students experiencing the highest burnout (mean=14.971). Family support emerged as a secondary factor for those with limited activity, reducing burnout (mean=8.741 vs. 11.473).

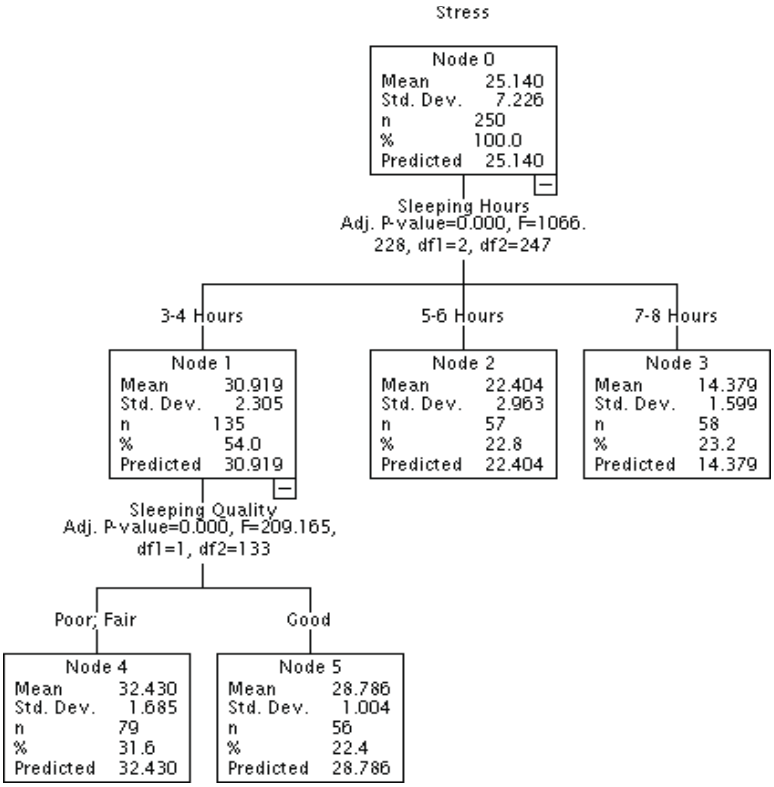

Figure 1: Decision Tree for Stress Predictors

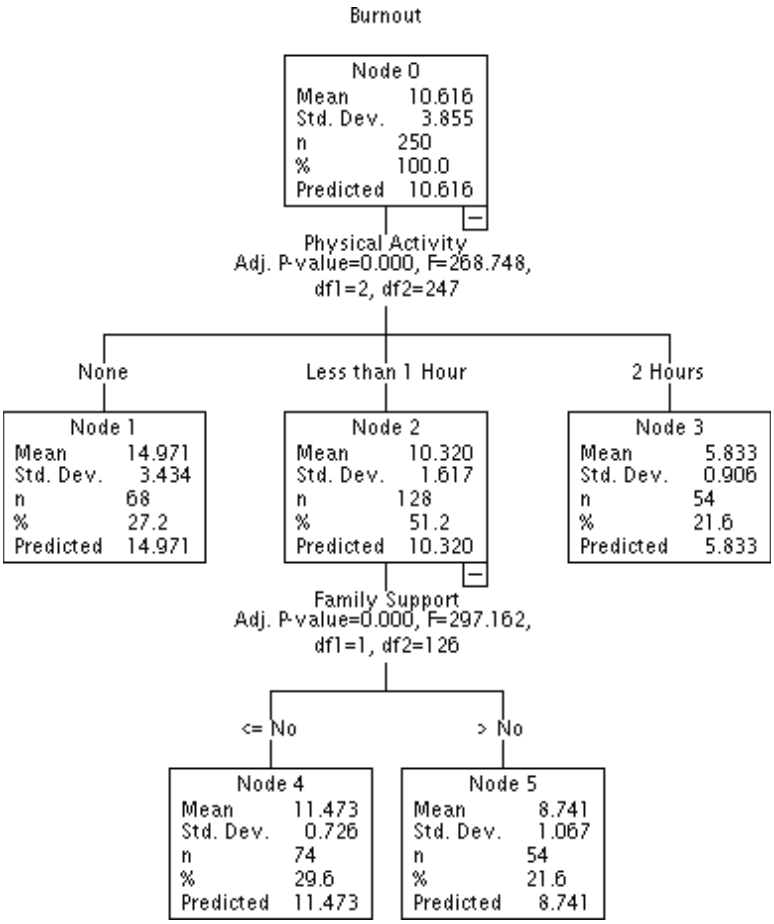

Figure 2: Decision Tree for Burnout Predictors

The CHAID decision tree identified high-risk profiles. For stress, students with less than four hours of sleep and poor quality were most vulnerable. High perfectionism exacerbated stress, particularly among those with low self-efficacy. For burnout, the most at-risk group included inactive students lacking family support. Weak self-efficacy increased burnout even among somewhat active students. Academic pressure overwhelmed the protective effect of moderate physical activity in some cases. These results emphasize that behavioral vulnerabilities (e.g., poor sleep, inactivity), psychological risks (e.g., perfectionism, low self-efficacy), and contextual disadvantages (e.g., low social support, academic stress) interact to elevate risk. Targeted interventions focusing on sleep hygiene, physical activity, and social support could mitigate these risks effectively.

DISCUSSION

This study explored the multifaceted relationship between behavioral, psychological, and environmental factors in predicting stress and burnout among medical students. Regression analysis identified perfectionism as the strongest predictor of stress, supporting the notion that high self-expectations and fear of failure contribute to chronic stress[17]. Notably, the impact of perfectionism was amplified in students with low self-efficacy, who may resort to maladaptive coping strategies like rumination and avoidance, further exacerbating distress[18]. Conversely, self-efficacy emerged as a key protective factor, correlating with reduced levels of both stress and burnout. This aligns with Bandura's self-efficacy theory, which posits that individuals with higher confidence in their abilities are better equipped to manage challenges and experience less stress[19]. The interplay between physical activity and self-efficacy in predicting burnout further underscores the importance of psychological resources, as low self-efficacy may hinder sustained motivation for exercise, diminishing its stress-buffering effects.

A novel finding from the decision tree analysis revealed that sleep quality moderates stress levels.

While previous research has established the link between sleep deprivation and stress, this study demonstrated that students who slept 4–6 hours but reported good sleep quality experienced significantly lower stress than those with poor-quality sleep[20]. This highlights the need for interventions addressing not only sleep duration but also sleep hygiene and underlying psychological issues like anxiety-induced insomnia.

Burnout, on the other hand, was more strongly predicted by physical inactivity and lack of social support than by psychological factors alone. These findings align with Maslach's theory of burnout, which emphasizes exhaustion, depersonalization, and reduced accomplishment as core components[21]. Physically inactive students exhibited higher burnout levels, likely due to missed physiological and psychological benefits of exercise, such as cortisol regulation and mood enhancement. Similarly, students lacking family support demonstrated elevated burnout, suggesting that external resources play a critical role in buffering emotional exhaustion and fostering resilience[22,23].

The decision tree analysis also revealed nonlinear interactions, such as the diminished protective effect of moderate physical activity under high academic stress. This underscores the importance of addressing cumulative risk factors rather than assuming uniform benefits of protective behaviors[24]. Practical implications include targeted interventions: improving sleep quality through cognitive-behavioral therapy for insomnia (CBT-I), enhancing self-efficacy via goal-setting and self-monitoring in exercise programs, and expanding social support systems to include mentorship and faculty engagement[25,26].

While regression analysis provided robust estimates of individual predictors, it could not detect conditional relationships. Decision tree analysis, though insightful in identifying interaction effects, was limited by its categorical nature. A mixed-methodological approach combining both models is recommended for deeper insights. Healthcare educational institutions must prioritize policies addressing perfectionism-driven stress, promoting resilience training, workload adjustments, and comprehensive support services that integrate behavioral and psychological dimensions of student well-being.

CONCLUSION

This study identified significant predictors and risk profiles for stress and burnout among medical students, emphasizing the complex interplay between individual traits and contextual factors. Perfectionism and low self-efficacy emerged as strong predictors of stress, while physical inactivity and lack of family support were closely associated with burnout. Decision tree analysis offered additional insights, notably the moderating role of sleep quality and the reduced protective effect of physical activity under high academic stress. These findings highlight the urgent need for targeted institutional interventions, including structured sleep hygiene education, physical wellness programs, and strengthened peer and family support systems. Furthermore, addressing maladaptive perfectionism through resilience training and faculty-led mentorship could help students develop healthier coping strategies.

Future studies should adopt longitudinal approaches to assess the persistence of these risk factors over time and evaluate the effectiveness of targeted interventions. The use of advanced predictive tools, such as machine learning, may further enhance the early detection and support of high-risk student populations.

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None

CONFLICT OF INTEREST

The authors declare no conflicts of interest regarding this study.

ETHICAL APPROVAL

The Ethical approval for the study was granted by the Institutional Review Board of Bakhtawar Amin Medical and Dental College (Ref No. 0663-24/E.C./BAM&DC).

AUTHORS' CONTRIBUTION

All authors equally contributed as per ICMJE.

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