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Learning Environment, Academic Stressors, and Institutional Aspects as Determinants of Mental Health Outcomes in Medical Education

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Abstract

Objective: Examine associations between learning environment, academic stressors, and mental health among Brazilian medical students across different institutional contexts.

Methods: Cross-sectional study of 1,026 medical students from 74 public and private universities. Participants completed the Patient Health Questionnaire-9 (PHQ-9), Generalized Anxiety Disorder-7 (GAD-7), Johns Hopkins Learning Environment Scale (JHLES), and Medical Student Stressor Factor Scale (MSSF). Analyses included group comparisons, multiple regression, random forest modeling, and latent class analysis.

Results: Private university students reported significantly better learning environments than public university counterparts (M = 84.6 vs. 81.9, $p < 0.001$). Quota students, those admitted to universities through affirmative action policies, demonstrated higher depression scores (M = 14.2 vs. 12.8, $p = 0.007$) and academic stress levels (M = 134.0 vs. 129.1, $p = 0.018$). Academic stressors demonstrated significant associations with both depressive ($\beta=0.103$; $p<0.001$) and anxiety symptoms ($\beta=0.103$; $p<0.001$), while higher learning environment quality was associated with lower depressive symptom severity ($\beta=-0.105$; $p=0.043$). Latent classes identified high-risk (53.7%), moderate-distress (32.7%), and high-functioning (13.6%) profiles, with affirmative-action students overrepresented in higher-risk classes.

Conclusion: Students admitted via affirmative action in public universities face compounded vulnerabilities. Interventions should focus on reducing academic stress and improving learning environments, especially in public institutions serving disadvantaged groups.

Keywords: Medical education; Mental health; Academic stress; Learning environment; Brazilian students

Introduction

Medical education is widely acknowledged as an extraordinarily demanding pathway characterized by dense didactic loads, high-stakes examinations, early clinical responsibilities, and pervasive expectations of excellence [1]. This training context is accompanied by strikingly elevated rates of psychological distress worldwide, with recent systematic reviews placing clinically significant depressive symptoms among medical students at approximately 27% and moderate-to-severe anxiety symptoms at 25–35%, figures that far exceed those observed in age-matched peers [2, 3]. Additional evidence demonstrates concerning rates of burnout, suicidal ideation, and academic disengagement among medical trainees [1, 2, 4]. These data underscore the urgency of identifying modifiable determinants of mental health outcomes in medical students, particularly environmental and institutional factors that may be amenable to intervention.

A growing body of work positions the learning environment, encompassing physical infrastructure, institutional culture, faculty–student dynamics, and peer climate, as a chief determinant of both academic and psychological trajectories [5, 6]. Supportive, intellectually stimulating environments are linked to stronger engagement, professional identity formation, empathy development, and resilience [7, 8]. In contrast, settings marked by mistreatment, excessive workload, and hyper-competition contribute to distress and burnout [9-11]. Yet the environment's influence is rarely direct; it is mediated through students' appraisal of academic stressors, including performance pressure, time constraints, interpersonal challenges, and health concerns [12, 13]. While moderate, well-scaffolded challenge fosters growth, unrelenting or poorly managed demands predict psychological morbidity and academic disengagement [14, 15].

Despite this emerging understanding, four critical gaps still limit our ability to develop targeted interventions. First, most studies examine learning environment and academic stressors separately, overlooking their interactive effects and relative contributions to mental health outcomes. Investigations that consider both factors often employ traditional regression approaches, which cannot adequately capture complex,

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non-linear relationships or rank the relative importance of multiple environmental dimensions and stressor categories. Second, few investigations employ advanced analytic strategies capable of identifying which specific environmental dimensions or stressor categories most strongly predict distress, limiting the precision of intervention targets. Third, studies examining how institutional characteristics, such as public versus private governance, affirmative action policies, and funding mechanisms, moderate these relationships remain scarce, particularly outside North America and Western Europe. This represents a significant limitation given the global diversity in medical education systems and access policies. Fourth, research utilizing person-centered approaches to identify distinct vulnerability profiles among medical students is notably absent, despite their potential to inform personalized intervention strategies and risk stratification.

The Brazilian context offers a unique opportunity to address these gaps. Over the past two decades, Brazil has seen a rapid expansion of medical schools, both public and private, leading to substantial variation in governance and pedagogical models. This expansion occurred alongside nationwide affirmative action policies aimed at increasing access for underrepresented groups. In public universities, quotas reserve a proportion of seats for students based on race/ethnicity and socioeconomic background. At the same time, private institutions and the Brazilian government often provide scholarships to support low-income and minority students. These mechanisms have created a uniquely diverse medical student population, offering a rich setting for studying educational equity [16, 17]. To address these knowledge gaps, the present study examines the relationship between learning environment quality and academic stressors, and their impact on depressive and anxiety symptoms among Brazilian medical students. It evaluates the relative importance of these factors through machine learning approaches and identifies distinct student vulnerability profiles across different institutional contexts.

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Methods

Study Design

This cross-sectional study included medical students from various institutions across Brazil. It was conducted between September 2023 and September 2024, following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) protocol (von Elm et al., 2007). Ethical approval was obtained from the Research Ethics Committee of the Hospital das Clínicas, Faculty of Medicine, University of São Paulo, Brazil (CAAE: 70017023.4.0000.00680).

Study Participants

The target population consisted of medical students enrolled in Brazilian higher education institutions (HEIs), aged 18 years or older, from the first to the sixth years of medical school. Participation was entirely voluntary, with no financial or academic incentives, and anonymity was maintained throughout the process. Only those who electronically accepted the informed consent form—considered an electronic signature—were included in the study. The initial sample size was estimated based on a total population of approximately 200,000 Brazilian medical students, using a 99% confidence level and a 5% margin of error. A minimum of 664 participants was deemed necessary to achieve adequate statistical power and ensure the validity of the study findings.

Data Collection Procedures

Between September 2023 and September 2024. Participants, participants were invited to participate via email, and upon providing informed consent, they received a structured, self-administered questionnaire electronically. The questionnaire was developed and distributed using the REDCap® platform. As part of the recruitment strategy, medical schools across Brazil were systematically mapped and selected by region to ensure proportional geographic distribution, and faculty members, academic coordinators, and student representatives were contacted to help distribute the study invitation and questionnaire link through official institutional communication channels.

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A key element in expanding the survey's reach was the collaboration with the Brazilian branch of the International Federation of Medical Students' Associations of Brazil (IFMSA-Brazil), which provided access to approximately 2,000 registered email contacts via a formal agreement signed by the organization's then-president. The dissemination efforts also involved contributions from the LEASH (Learning Environment and Academic Safety in Higher Education Study – Research Group) Collaborators.

There were no academic or financial incentives offered; participation was entirely voluntary. To maximize response rates, a structured follow-up protocol was implemented, including reminder emails sent every four weeks to initial non-respondents throughout the half-year data collection period. After this period, a second round of invitations was sent to encourage additional responses. These procedures aimed to recruit a robust and representative sample.

Instruments

- Demographic and educational covariates: The authors designed a questionnaire covering Participants' Demographic, Socioeconomic, and Academic Characteristics. Data collected included: Age (years), treated as a continuous variable after checking for normality, biological sex (male/female), recorded as a binary variable and analyzed categorically, and gender, treated as a nominal variable. Self-declared race/ethnicity (White, Brown, Black, Asian, and Indigenous) was recorded and, when necessary, dichotomized as White versus Non-White. In analyses, it was kept as a five-level categorical variable due to sufficient group representation. The year of study was reported by academic semester (1–12), corresponding to six potential years of medical education. To standardize reporting and facilitate comparison with institutions operating on an annual system, semesters were grouped into academic years as follows: pre-clinical (1st–2nd year: semesters 1–4), clinical (3rd–4th year: semesters 5–8), and clerkship (5th–6th year: semesters 9–12). For regression and structural equation modeling, the academic year was treated as a continuous variable (1–6).

Scholarship status (yes/no), type of institution (public/private), and quota admission (yes/no) were coded as binary categorical variables and included as potential confounders or moderators in the analyses. Quota admission refers to Brazil's legally mandated affirmative action policies that reserve a proportion of seats in public universities for students from historically underrepresented groups. These include racial/ethnic minorities (self-identified as Black, Brown, or Indigenous), students from low-income households, individuals with disabilities, and those who attended public high schools. These categories were predefined and self-reported by participants. Scholarship status was assessed based on whether students received financial support to attend private universities. This included federal programs such as the University for All Program (PROUNI), which offers full or partial tuition waivers for low-income students, and the Higher Education Student Loan Fund (FIES), which provides low-interest loans. Institutional support scholarships granted directly by private universities were also considered.

- Learning environment: The Johns Hopkins Learning Environment Scale (JHLES) comprises 28 items scored on a 5-point Likert scale and clusters into seven dimensions: Faculty Relationships (FR), Peer Collaboration (COP), Academic Climate (AC), Meaningful Engagement (ME), Physical Space (PS), Inclusion & Acceptance of Student Diversity (IAS) and Mentorship (M). In the original U.S. sample, the total scale showed excellent internal consistency (α = 0.89) and a stable seven-factor structure (Shochet et al., 2015). A Brazilian Portuguese version, produced through forward–back translation and cognitive debriefing, replicated the factorial solution (CFI = 0.93, RMSEA = 0.05) and yielded α = 0.93 and a test-retest ICC of 0.82 among 556 students (Damiano et al., 2020). The JHLES total score was calculated by summing all 28 items (Cronbach's α = 0.94), with subscale scores computed for Faculty Relationships, Peer Collaboration, Academic Climate, Meaningful Engagement, Physical Space, Inclusion and Acceptance, and Mentoring. Higher scores denote a more supportive environment.

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- Medical Student Stressor Factor Scale (MSSF): Developed from qualitative interviews and survey data with Brazilian medical students, the 28-item MSSF assesses the perceived stressfulness of each situation on a 5-point scale. Exploratory-confirmatory analyses produced five domains—Learning & Academic Performance (LEAAP), Relationships (REL), Health Concerns (HEA), Lack of Time (LOT), and Learning Issues (LI). The instrument demonstrated excellent reliability (total α = 0.92; domain α = 0.78–0.88) and temporal stability over a six-week period (ICC = 0.85) (Damiano et al., 2021). The MSSF total score comprised 28 items (α = 0.93) and higher scores reflect greater perceived stress.
- Patient Health Questionnaire-9 (PHQ-9): The PHQ-9 is a nine-item, DSM-IV aligned self-report that screens and grades depressive severity (0–27). PHQ-9 depression severity categories followed standard clinical thresholds: minimal (0-4), mild (5-9), moderate (10-14), moderately severe (15-19), and severe (20-27). GAD-7 anxiety categories included minimal (0-4), mild (5-9), moderate (10-14), and severe (15-21). In primary care, the original study reported α = 0.89 and optimal sensitivity 77 % specificity 86 % for major depression at ≥10 points (Kroenke et al., 2001). The Brazilian translation (Fraguas et al., 2006) retains an α ≈ of approximately 0.86 and an AUC ≈ of approximately 0.89 against MINI diagnoses.
- Generalized Anxiety Disorder-7 (GAD-7): The GAD-7 contains seven items scored 0–3 (0–21 total). The seminal validation reported α = 0.92 with a 89% sensitivity and 82% specificity for generalized anxiety at ≥10 points (Spitzer et al., 2006). A Brazilian community study confirmed unidimensionality and high reliability (α = 0.92) (Moreno et al., 2016). Severity bands follow standard cut-offs: minimal (0–4), mild (5–9), moderate (10–14), and severe (15–21).

Statistical Analyses

All statistical analyses were conducted using R version 4.3.0 with comprehensive data preprocessing and quality control procedures. Prior to analysis, we systematically evaluated data integrity by examining missing value patterns and assessing distributional assumptions. Missing data patterns were comprehensively documented,

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with Little's MCAR test confirming data were missing completely at random. For primary analyses, we employed listwise deletion to maintain analytical rigor, while correlation analyses used pairwise deletion to maximize statistical power.

Descriptive and Comparative Statistics

Comprehensive descriptive statistics were computed for all variables, including measures of central tendency and variability. We conducted three primary comparative analyses based on key institutional characteristics: (1) public versus private universities, (2) quota versus non-quota students, and (3) scholarship recipients versus non-recipients.

For continuous variables, we used independent samples t-tests after confirming normality assumptions via Shapiro-Wilk tests. For categorical variables, we applied Pearson's chi-square tests of independence, with Fisher's exact tests used when the expected cell frequencies were below 5. Statistical significance was set at $p < 0.05$, with Bonferroni correction applied for multiple comparisons within each analysis domain.

Hierarchical Regression Modeling

We employed multiple linear regression to examine predictors of depressive symptoms (PHQ-9) and anxiety symptoms (GAD-7). Our final models included theoretically relevant predictors: learning environment quality (JHLES total score), academic stressors (MSSF total score), demographic variables (age, gender, race), and institutional context variables (university type, quota status, scholarship status).

Model assumptions were rigorously evaluated through residual analysis, including tests for linearity, homoscedasticity (Breusch-Pagan test), and multicollinearity (variance inflation factors < 5.0). Effect sizes were interpreted using Cohen's conventions, with standardized beta coefficients reported alongside 95% confidence intervals.

Variable Importance Analysis

To identify the most influential predictors of mental health outcomes, we implemented Random Forest modeling using 1,000 trees with variable importance quantified through mean decrease in accuracy measures. This machine learning

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approach provided robust rankings of predictor importance while accounting for complex interactions between variables. All JHLES and MSSF subscales were included alongside demographic and institutional variables to create comprehensive importance rankings for both anxiety and depressive symptoms.

Latent Class Analysis

We conducted Latent Class Analysis (LCA) using the poLCA package to identify distinct student profiles based on learning environment quality, levels of academic stressors, and patterns of mental health symptoms. Variables were categorized into meaningful clinical groups for LCA inclusion: learning environment scores (tertiles: low, moderate, high), academic stressor scores (tertiles), depression severity (minimal, mild, moderate-severe), and anxiety severity (minimal, mild, moderate-severe).

Model selection employed information criteria (AIC, BIC) and interpretability considerations, testing solutions with 2-5 classes. The optimal model was selected based on the lowest BIC values and clinical interpretability. Class membership probabilities were computed using maximum likelihood estimation, and resulting profiles were comprehensively characterized across all measured dimensions, including demographic, institutional, and clinical variables.

Analyses employed R version 4.3.0 with packages: tidyverse (2.0.0), psych (2.3.6), randomForest (4.7-1.1), poLCA (1.6.0), car (3.1-2), and ggplot2 (3.4.2). All analyses adhered to the principles of reproducible research, incorporating seed setting for random processes. Model validation included assessment of residual patterns, influence diagnostics using Cook's distance, and bootstrap validation for regression coefficients. For Random Forest models, out-of-bag error rates were computed to assess prediction accuracy. LCA model adequacy was evaluated using entropy measures and posterior classification probabilities.

Effect sizes were interpreted using established conventions for research in the behavioral sciences. For regression analyses, we calculated Cohen's f^2 values to assess both practical and statistical significance. Standardized beta coefficients facilitated the comparison of relative predictor importance. Clinical significance was evaluated by examining whether the observed differences exceeded the established

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minimal clinically significant differences for the PHQ-9 (≥5 points) and GAD-7 (≥4 points) scales.

All analyses emphasized both statistical significance ($p < 0.05$) and practical importance, with confidence intervals provided to facilitate interpretation and future meta-analytic synthesis. The analytic approach prioritized transparency and reproducibility while maintaining focus on clinically meaningful findings that could inform educational and mental health interventions in medical training environments.

Results

Participant Characteristics (Table 1)

A total of 1,026 Brazilian medical students from 74 medical schools participated in this study, representing approximately 0.40% of the total population of 266,507 medical students enrolled in Brazilian medical schools in 2023 (data from the National Institute of Educational Studies and Research Anísio Teixeira Higher Education Census). The mean age was 24.9 years (SD = 8.8), and 63.9% of the participants were female. Among the 1024 students with valid gender identity data, the distribution was as follows: cisgender 1009 (98.54%), transgender 4 (0.39%), intersex 3 (0.29%), queer 4 (0.39%), and non-binary 4 (0.39%). Students were enrolled across both public (413, 40.3%) and private (611, 59.6%) medical schools. Among the 1,026 medical students, 186 (18.13%) were in 1st year, 118 (11.50%) in 2nd, 209 (20.37%) in 3rd, 263 (25.63%) in 4th, 128 (12.48%) in 5th, and 120 (11.70%) in 6th year; academic year was missing for 2 (0.19%) students. Regarding admission pathways, 23.2% (n = 238) of students were admitted through quota systems. Among public university students, 42.6% were quota beneficiaries, compared to 10.1% in private institutions, reflecting Brazil's affirmative action policies, which primarily target public higher education. Additionally, 14.0% (n = 131) received any kind of financial support. The financial support distribution revealed that 0.5% of public university students and 23.4% of private university students received such support, highlighting the distinct funding mechanisms across institutional contexts.

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Table 1. Participants' Characteristics

Characteristic	Value
Total Sample, n	1026
Age (years), mean ± SD	24.9 ± 8.8
Biological Sex, n (%)	
Female	654 (63.9)
Male	370 (36.1)
Gender, n (%)	
Cisgender	1009 (98.54)
Transgender	4 (0.39)
Intersex	3 (0.29)
Queer	4 (0.39)
Non-binary	4 (0.39)
Missing	2 (0.19)
University Type, n (%)	
Public	413 (40.3)
Private	611 (59.7)
University Year, n (%)	
1st	186 (18.13)
2nd	118 (11.50)
3rd	209 (20.37)
4th	263 (25.63)
5th	128 (12.48)
6th	120 (11.70)
Missing	2 (0.19)
Quota Students, n (%)	238 (23.2)
Scholarship Recipients, n (%)	131 (14)
Mental Health Outcomes	
Depressive Symptoms (PHQ-9), mean ± SD	13.1 ± 6.7
Anxiety Symptoms (GAD-7), mean ± SD	10.3 ± 6.1
Learning Environment and Stressors	
Learning Environment Score (JHLES), mean ± SD	83.4 ± 13.3
Academic Stressors Score (MSSF), mean ± SD	130.1 ± 28.3

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Mental Health Outcomes and Group Differences (Table 2)

The overall prevalence of mental health symptoms was substantial. Mean PHQ-9 depression scores were 13.1 (SD = 6.7), with 676 students (66.0%) meeting criteria for moderate-to-severe depression (PHQ-9 ≥ 10). Similarly, mean GAD-7 anxiety scores

were 10.3 (SD = 6.1), with 517 students (50.5%) experiencing moderate-to-severe anxiety symptoms (GAD-7 ≥ 10). Students reported moderate levels of learning environment quality (JHLES total: M = 83.4, SD = 13.3) and substantial academic stressors (MSSF total: M = 130.1, SD = 28.3).

Students in private universities reported significantly more positive learning environments compared to their public university counterparts (JHLES total: M = 84.6 vs. M = 81.9, $p < 0.001$). Specifically, private university students scored higher on faculty relationships (M = 20.1 vs. M = 18.0, $p < 0.001$) and academic climate (M = 15.6 vs. M = 14.2, $p < 0.001$).

Students admitted through quota systems reported significantly higher depression scores (PHQ-9: M = 14.2 vs. M = 12.8, $p = 0.007$) and greater academic stressor levels (MSSF total: M = 134.0 vs. M = 129.1, $p = 0.018$) compared to non-quota students. Scholarship recipients reported lower peer collaboration scores (M = 14.5 vs. M = 15.9, $p < 0.001$) and meaningful engagement scores (M = 13.0 vs. M = 13.9, $p = 0.001$) compared to non-recipients.

Factors Associated with Mental Health Outcomes (Table 3)

The final regression model explaining depressive symptoms achieved good model fit ($R^2 = 0.429$, adjusted $R^2 = 0.378$; $F(8, 89) = 8.37$, $p < 0.001$). Academic stressors demonstrated the strongest association with depressive symptoms ($\beta = 0.103$, SE = 0.023, $p < 0.001$), with each one-unit increase in academic stressor scores corresponding to a 0.103-point increase in depression scores. Higher learning environment quality was significantly associated with lower depression severity ($\beta = -0.105$, SE = 0.051, $p = 0.043$), suggesting a potential protective relationship that warrants longitudinal investigation.

The anxiety model demonstrated similar performance ($R^2 = 0.408$, adjusted $R^2 = 0.355$; $F(8, 89) = 7.67$, $p < 0.001$). Academic stressors again emerged as the primary correlate ($\beta = 0.103$, SE = 0.021, $p < 0.001$), while the association with learning environment quality was not significant ($\beta = -0.072$, SE = 0.046, $p = 0.117$).

Random Forest analysis identified the most influential correlates of mental health outcomes across all measured variables, with lack of time (MSSF) being the most

BJP PRE-PROOF

important predictor for both outcomes (Figure 1). For both depression and anxiety, the top three correlates were consistently lack of time (MSSF), health concerns (MSSF), and relationship stressors (MSSF), in that order. Notably, all top-ranking predictors were stressor domains rather than protective factors, while learning environment dimensions (Figure 2) emerged as protective factors with more modest variable importance, particularly peer collaboration and academic climate for depression outcomes.

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Figure 1. Top 15 Most Important Predictors from Random Forest Analysis

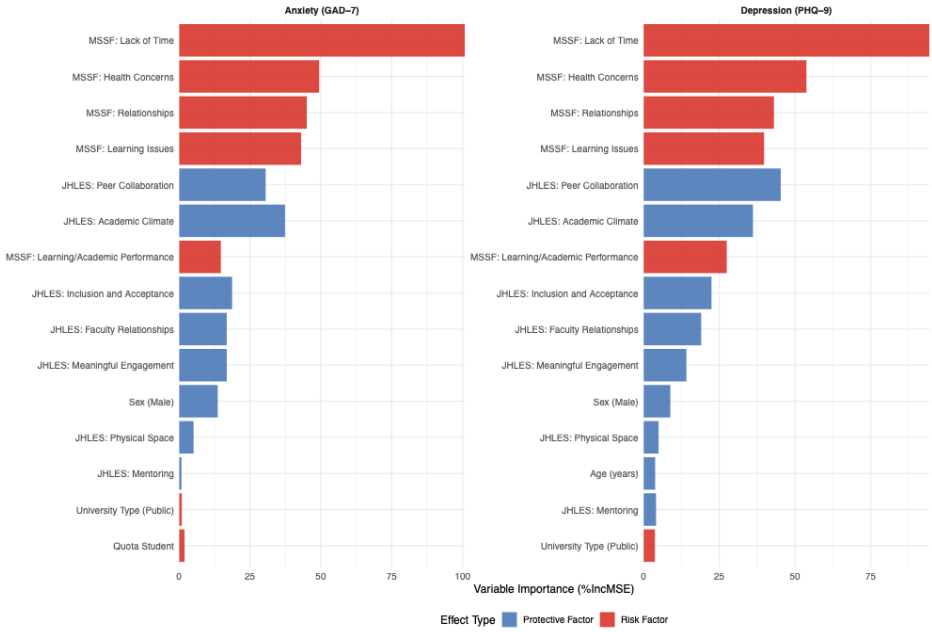
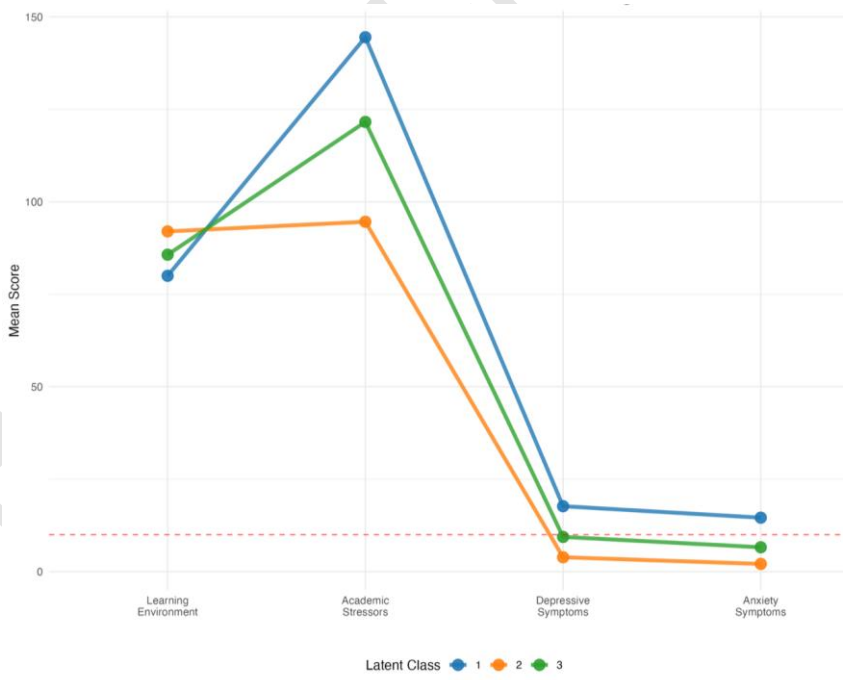


Figure 2. Latent Class Profiles: Mental Health and Learning Context



Note: Three distinct student profiles emerged from latent class analysis based on learning environment quality, academic stress levels, and mental health symptoms: Class 1 (53.7% of sample): "High-distress" profile characterized by poor learning environments, elevated stress, and severe mental health symptoms; Class 2 (13.6% of sample): "Low-distress" profile characterized by positive learning environments, moderate stress, and minimal mental health symptoms; Class 3 (32.7% of sample): "Moderate-distress" profile characterized by intermediate

learning environments, elevated stress, and moderate mental health symptoms. JHLES = Johns Hopkins Learning Environment Scale; MSSF = Medical Student Stressor Factor Scale; PHQ-9 = Patient Health Questionnaire-9 (depression); GAD-7 = Generalized Anxiety Disorder-7 Scale (anxiety).

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Table 2. Participant Characteristics and Group Comparisons

Variable	Total Sample	Public University	Private University	Quota Students	Non-Quota Students	Scholarship Recipients	No Scholarship
Mental Health Outcomes							
PHQ-9 score, mean ± SD	13.1 ± 6.7	13.4 ± 6.8	12.9 ± 6.6	**14.2 ± 7**	**12.8 ± 6.6****	13.8 ± 7.3	12.9 ± 6.6
GAD-7 score, mean ± SD	10.3 ± 6.1	10.3 ± 6.2	10.3 ± 6.1	10.9 ± 6.2	10.1 ± 6.1	10.6 ± 6.4	10.3 ± 6.1
Learning Environment							
JHLES Total score, mean ± SD	83.4 ± 13.3	**81.9 ± 11.8**	**84.6 ± 13.4*****	**81.9 ± 12.2**	**83.9 ± 13.3***	82.5 ± 12.9	83.5 ± 12.8
Faculty Relationships	19.3 ± 5.6	**18 ± 5**	**20.1 ± 5.8*****	**18.3 ± 5.4**	**19.6 ± 5.6****	19.3 ± 5.4	19.1 ± 5.6
Peer Collaboration	15.7 ± 4.1	**16.2 ± 4.2**	**15.4 ± 4****	15.4 ± 4.3	15.8 ± 4.1	**14.5 ± 4.1**	**15.9 ± 4.1*****
Academic Climate	15 ± 3.8	**14.2 ± 3.7**	**15.6 ± 3.8*****	**14.2 ± 3.8**	**15.2 ± 3.8*****	15.1 ± 3.8	14.9 ± 3.8
Meaningful Engagement	13.8 ± 2.9	**14.3 ± 2.7**	**13.5 ± 3*****	14 ± 2.7	13.8 ± 2.9	**13 ± 3.3**	**13.9 ± 2.8****
Physical Space	7.2 ± 1.6	**7 ± 1.6**	**7.4 ± 1.6*****	7.2 ± 1.6	7.3 ± 1.7	7.3 ± 1.7	7.2 ± 1.6
Inclusion and Acceptance	10.8 ± 2.6	**10.1 ± 2.6**	**11.2 ± 2.5*****	**10 ± 2.8**	**11 ± 2.5*****	10.7 ± 2.7	10.8 ± 2.6
Mentoring	6.9 ± 1.9	**7 ± 1.9**	**6.8 ± 1.9***	7 ± 1.8	6.8 ± 1.9	6.8 ± 1.9	6.9 ± 1.9
Academic Stressors							
MSSF Total score, mean ± SD	130.1 ± 28.3	131.7 ± 27.3	129.2 ± 28.5	**134 ± 28.3**	**129.1 ± 27.9***	131.6 ± 28.7	130.1 ± 27.8
Learning/Academic Performance	56.7 ± 12.5	**57.8 ± 12**	**55.9 ± 12.8***	**58.5 ± 12.3**	**56.1 ± 12.5****	57.9 ± 12.8	56.5 ± 12.3
Relationships	23.6 ± 5.6	23.6 ± 5.3	23.6 ± 5.8	**24.4 ± 5.7**	**23.4 ± 5.6***	24 ± 6.2	23.5 ± 5.5
Health Concerns	14.5 ± 5.3	**15 ± 5.3**	**14.1 ± 5.3***	**15.1 ± 5.2**	**14.3 ± 5.3***	14.4 ± 5.3	14.5 ± 5.3
Lack of Time	16.9 ± 4.2	16.8 ± 4.3	17 ± 4.2	17 ± 4.2	16.9 ± 4.3	17.1 ± 4	17 ± 4.2
Learning Issues	18.6 ± 5.7	18.6 ± 5.5	18.6 ± 5.9	19 ± 5.8	18.4 ± 5.7	18.2 ± 5.9	18.7 ± 5.6

Note: *p<0.05, **p<0.01, ***p<0.001. P-values calculated using Student's t-test for continuous variables and Chi-square test for categorical variables. JHLES = Johns Hopkins Learning Environment Scale (higher scores indicate more positive perceptions); MSSF = Medical Student Stressor Factor scale (higher scores indicate greater stress); PHQ-9 = Patient Health Questionnaire-9; GAD-7 = Generalized Anxiety Disorder-7 scale.

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Student Profiles (Figure 2)

Latent class analysis revealed three distinct student profiles based on learning environment quality, academic stress levels, and mental health symptoms (BIC = 7,601.7).

- Class 1 (549 students, 53.7%): "High-distress" profile characterized by poor learning environments (M = 80.0), elevated stress levels (M = 144.5), and severe mental health symptoms (depression M = 17.7; anxiety M = 14.6). This class included 71.4% female students, with a mean age of 24.7 years; 40.3% attended public institutions and 59.7% attended private institutions; 14.3% held scholarships.
- Class 2 (139 students, 13.6%): "Low-distress" profile characterized by positive learning environments (M = 92.0), moderate stress levels (M = 94.6), and minimal mental health symptoms (depression M = 3.9; anxiety M = 2.1). This class included 46.8% female students, with a mean age of 25.4 years; 35.3% attended public institutions and 64.7% attended private institutions; 13.6% held scholarships.
- Class 3 (335 students, 32.7%): "Moderate-distress" profile characterized by poor learning environments (M = 85.7), elevated stress levels (M = 121.6), and moderate mental health symptoms (depression M = 9.4; anxiety M = 6.6). This class included 58.5% female students, with a mean age of 25.0 years; 42.4% attended public institutions and 57.6% attended private institutions; 13.7% held scholarships.

The high-functioning class (Class 2) represented only 13.6% of the total sample, while the majority of students (53.7%) fell into the high-distress category.

Discussion

This comprehensive cross-sectional study of 1,026 Brazilian medical students from 74 institutions reveals an alarming prevalence of psychological distress, with 66.0% experiencing moderate-to-severe depression and 50.5% moderate-to-severe anxiety—rates substantially exceeding both international and national

BJP PRE-PROOF

estimates. Cluster analysis identified three distinct student profiles: only 13.6% belonged to a low-distress category, while 53.7% fell into a high-distress classification, indicating widespread psychological vulnerability across the population. Institutional stratification revealed significant disparities, with public universities demonstrating poorer learning environment quality and quota students exhibiting elevated levels of depression and academic stress. Academic stressors demonstrated the strongest associations with mental health outcomes in our analyses, with "lack of time" accounting for approximately 45-50% of variable importance in predicting both anxiety and depression. Learning environment factors showed modest but statistically significant protective associations. However, the directionality and temporal sequence of these relationships require confirmation through prospective longitudinal investigations before definitive causal inferences can be drawn.

These findings reveal psychological distress rates that substantially exceed both global benchmarks and national estimates. The observed prevalence of moderate-to-severe depression (66.0%, PHQ-9 ≥ 10) and anxiety (50.5%, GAD-7 ≥ 10) considerably surpasses recent meta-analytic findings from international medical student populations reporting depression prevalence of 27.2% and anxiety prevalence of 33.8%[2, 3], as well as pooled Brazilian estimates of 30.6% for depression and 32.9% for anxiety[18]. However, these prevalence figures must be interpreted with caution given the potential for selection bias inherent in our sampling methodology. The response rate of approximately 0.40% of Brazil's national medical student population suggests that students experiencing greater psychological distress may have been disproportionately motivated to participate, potentially inflating absolute prevalence estimates[19]. Importantly, this selection bias primarily affects the external validity of prevalence figures rather than the internal validity of observed associations between learning environment quality, academic stressors, and mental health outcomes—the core focus of our investigation[20]. Nonetheless, the elevated rates observed align with broader evidence documenting substantial psychological distress burdens among medical students

BJP PRE-PROOF

in low- and middle-income countries[21], suggesting systemic challenges within Brazilian medical education that warrant urgent attention.

Institutional stratification revealed significant disparities, with public universities demonstrating lower learning environment quality and quota students exhibiting elevated depression scores and academic stressor burden. Latent class analysis identified that only 13.6% of students belonged to a "low-distress" profile, while 53.7% were classified as "high-risk," indicating widespread psychological vulnerability requiring urgent intervention. This pattern aligns with global reports indicating that improving learning environments in medical education remains a persistent challenge, with multifactorial barriers to sustainable change [22]. Multiple regression models demonstrated robust associations between academic stressors and mental health outcomes among students who completed the surveys, with academic stressors explaining substantial variance in both depressive and anxiety symptoms. These effect sizes align with theoretical frameworks proposing academic demands as primary determinants of medical student distress [9, 23-25]. Random Forest variable importance analysis revealed "lack of time" as the most influential predictor for both anxiety and depression, accounting for approximately 45-50% of variable importance scores. This finding is particularly significant given the intensive nature of medical curricula, where students must balance extensive didactic requirements, clinical rotations, examination preparation, and personal obligations within rigid temporal constraints [1]. Health concerns and relationship stressors emerged as secondary predictors, suggesting that academic demands create cascading effects that compromise students' physical well-being and social connections.

The prominence of temporal constraints as the primary correlate of psychological distress has direct implications for curriculum reform and institutional policy. Evidence-based interventions targeting time-related stressors include implementing structured curriculum audits to eliminate redundant content, introducing flexible scheduling with protected time for rest and self-directed learning, adopting longitudinal integrated clerkship models, and distributing assessments more evenly throughout the academic year[26-28]. These structural

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modifications address root causes of time scarcity as systemic rather than individual-level problems. For instance, reducing competitive grading pressures and adopting less ranking-focused assessment systems have been associated with improved psychological well-being without compromising academic performance or clinical competency[29]. Implementation of such reforms requires sustained institutional commitment and continuous evaluation to ensure educational quality is preserved.

Learning environment factors demonstrated meaningful protective effects, with peer collaboration and academic climate emerging as key protective factors for both anxiety and depression outcomes. This finding aligns with prior evidence indicating that strong social support networks [7], mentorship programs [30], extracurricular activities (Dyrbye et al., 2006; Henning et al., 2011), and institutional policies that reduce excessive academic workload [28] serve as multifaceted protective factors against psychological distress. Faculty relationships and inclusion/acceptance showed moderate protective associations, while learning environment quality demonstrated significant protective associations with depression but not anxiety, suggesting that environmental interventions may be more efficacious for depressive symptoms through mechanisms involving social support, academic engagement, and institutional belonging. The asymmetric relationship between stressors and protective factors indicates that while negative academic demands exert powerful, detrimental effects, positive environmental characteristics provide meaningful but more modest buffering effects [10, 12, 27, 31]. Based on the observed cross-sectional associations, several potential intervention strategies warrant prospective evaluation. Curricular modifications that reduce academic overload, introduce flexible deadlines, and implement less punitive assessment systems (e.g., pass/fail grading) have shown preliminary efficacy in prior research for reducing depressive symptoms and burnout[27]. However, the implementation of such interventions in the Brazilian context requires rigorous evaluation through randomized controlled trials or quasi-experimental designs to establish causal efficacy and ensure contextual appropriateness.

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An important pattern emerging from the multivariate regression analyses warrants explicit discussion: the absence of significant independent associations between mental health outcomes and demographic/institutional variables (quota status, race/ethnicity, university type) after statistical adjustment for learning environment quality and academic stressor levels (Table 3). This finding contrasts with the significant bivariate associations observed for these variables (Table 2), suggesting that their relationships with psychological distress may be primarily mediated through environmental and stressor pathways rather than operating through direct mechanisms. Specifically, the elevated depression and anxiety symptoms observed among quota students and those in public universities in unadjusted analyses appear to reflect their exposure to poorer learning environments and heightened academic stress rather than inherent vulnerabilities associated with demographic characteristics or institutional affiliation per se. This pattern aligns with contemporary social-ecological frameworks emphasizing that health disparities often emerge through differential exposure to adverse environmental conditions rather than intrinsic group differences[32, 33]. From an intervention perspective, this suggests that efforts to reduce mental health inequities should prioritize structural improvements—enhancing learning environment quality and reducing excessive academic stressors, including addressing institutional violence, bullying, hazing, and harassment, which disproportionately affect vulnerable populations[33, 34]. It is important to emphasize that targeted support programs for underrepresented students remain essential and should be strengthened rather than replaced. However, our findings suggest that universal structural improvements addressing learning environments and academic workload may constitute a particularly effective complementary strategy, as these interventions benefit all students while reducing the disproportionate burden experienced by those from disadvantaged backgrounds. This integrated approach, combining robust support for vulnerable groups with systemic environmental reforms, represents the most comprehensive pathway toward achieving equity in medical student mental health outcomes, addressing both

BJP PRE-PROOF

immediate support needs and the underlying structural determinants of disparities[35, 36].

Table 3. Linear Regression Models Predicting Anxiety (GAD-7) and Depressive Symptoms (PHQ-9)

Predictor	Depressive Symptoms β (SE)	p-value	Anxiety Symptoms β (SE)	p-value
Intercept	12.422 (6.772)	**0.07**	4.39 (6.043)	0.469
Learning Environment Score (JHLES)	-0.105 (0.051)	**0.043**	-0.072 (0.046)	0.117
Academic Stressors Score (MSSF)	0.103 (0.023)	**<0.001**	0.103 (0.021)	**<0.001**
Age (years)	-0.071 (0.075)	0.348	-0.012 (0.067)	0.856
Gender (Male vs Female)	-2.184 (1.232)	0.08	-0.823 (1.099)	0.456
Race (Non-White vs White)	0.358 (1.275)	0.779	-0.219 (1.138)	0.848
University Type (Public vs Private)	-1.183 (1.479)	0.426	-0.675 (1.319)	0.61
Quota Status (Quota vs Non-Quota)	-1.36 (1.498)	0.366	-0.693 (1.337)	0.605
Scholarship (Yes vs No)	0.823 (1.844)	0.657	1.366 (1.646)	0.409

Model Parameters: Depressive Symptoms: $R^2 = 0.429$; Adjusted $R^2 = 0.378$; $F(8, 89) = 8.37$; AIC = 626.9; BIC = 652.7. Anxiety Symptoms: $R^2 = 0.408$; Adjusted $R^2 = 0.355$; $F(8, 89) = 7.67$; AIC = 604.5; BIC = 630.4.

The institutional analysis reveals systematic inequities that compound socioeconomic disadvantage through structural differences between public and private medical education systems in Brazil. Public institutions, which enroll the majority of quota students (42.6% vs. 10.1% in private universities), demonstrate significantly compromised educational climates characterized by lower faculty relationship quality, diminished academic climate scores, and reduced overall learning environment quality. This pattern reflects Brazil's bifurcated higher education system, where public institutions face resource constraints that disproportionately affect quota students. In contrast, private institutions provide financial support to 23.4% of students compared to merely 0.5% in public universities, a 47-fold difference in scholarship availability. Furthermore, scholarship recipients demonstrated significantly lower peer collaboration scores

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and meaningful engagement levels, suggesting that financial aid mechanisms may generate social stratification effects through time allocation conflicts between work obligations and peer interaction. Research demonstrates that quota students achieved significantly lower dropout rates (3.4% vs. 17.9% for regular path students), equivalent admission rates to medical residency programs in multivariate analysis, and comparable long-term professional outcomes including similar monthly income, job satisfaction, employment opportunities, and management activities in both public and private health sectors, effectively contradicting the minority mismatch hypothesis and supporting affirmative action as an instrument to promote diversity and equity in medical education [37].

Additionally, national data from ENADE (National Student Performance Exam) demonstrate that public medical schools consistently outperform private institutions in students' scores, suggesting comparable or even superior academic preparedness among public-school entrants [17]. These findings suggest that achieving educational equity necessitates substantial investment in public medical education infrastructure, rather than relying solely on access expansion through quota systems. Moreover, implementing more rigorous certification standards for medical schools could ensure consistent quality across institutions, while enhanced coordination through national medical education organizations (such as ABEM and SAEME) could facilitate systematic improvements in curriculum design, faculty development, and student support services. Such comprehensive reforms would address the underlying structural factors contributing to disparities in student outcomes, ultimately creating more equitable learning environments that support the success of all medical students regardless of their socioeconomic background or admission pathway.

The latent profile analysis offers novel insights into medical student vulnerability patterns through person-centered analytical approaches that are rarely employed in medical education research. The three-class solution revealed distinct phenotypes: a high-distress class (53.7%) characterized by severe psychological distress and poor environmental perceptions, a moderate-distress class (13.6%) with minimal symptoms and positive environments (JHLES M = 92.0), and a

BJP PRE-PROOF

moderate-distress class (32.7%) with intermediate characteristics. The overrepresentation of public university students and quota beneficiaries in higher-risk classes (40.4% and 24.8%, respectively, in Class 1) demonstrates how institutional and socioeconomic factors interact to create vulnerability profiles that transcend individual-level characteristics. These findings challenge universal intervention approaches and support precision medicine paradigms in medical education that tailor support strategies to specific risk phenotypes. The identification of distinct profiles also suggests that early screening and risk-stratification protocols could enable proactive intervention before psychological distress becomes clinically significant.

Several methodological limitations constrain the interpretability and generalizability of these findings. Most critically, the cross-sectional design fundamentally precludes causal inference regarding the directionality of observed associations between learning environment quality, academic stressors, and mental health outcomes. Bidirectional relationships are plausible - for instance, students experiencing greater psychological distress may perceive their learning environments more negatively, while adverse environmental conditions may independently contribute to symptom development. Only prospective longitudinal investigations with multiple assessment points can establish temporal precedence, disentangle these reciprocal relationships, and examine developmental trajectories throughout medical training. Consequently, all intervention recommendations should be interpreted as hypothesis-generating rather than evidence-based guidance pending experimental validation. The convenience sampling methodology, while geographically diverse across 74 institutions, may introduce selection bias and limit the representativeness of smaller or newly established medical schools. The exclusive reliance on self-report instruments introduces potential measurement error through recall bias and social desirability effects. However, the utilization of validated Portuguese-language scales with established psychometric properties mitigates some concerns. The absence of clinical diagnostic assessments prevents differentiation between subclinical symptoms and diagnosable psychiatric disorders, limiting the clinical application of prevalence

BJP PRE-PROOF

estimates. Unmeasured confounding variables, including pre-medical academic performance, family socioeconomic status, prior mental health history, and personality factors, may partially account for observed associations and require incorporation in future multivariate models. Finally, the tendency for individuals with more severe conditions to be overrepresented among survey respondents may introduce selection bias.

Although these limitations do lead to a need for replication with a more representative sample, this investigation suggests a mental health crisis in Brazilian medical education, with prevalence rates of moderate-to-severe depression (66.0%) and anxiety (50.5%) substantially exceeding international benchmarks by more than twofold. The identification of temporal constraints as the primary correlate of psychological distress, followed by health concerns and relationship stressors, establishes a hierarchical framework for evidence-based interventions prioritizing time management and curriculum restructuring initiatives. Learning environment quality demonstrated significant protective effects, particularly through peer collaboration and academic climate mechanisms, indicating that institutional improvements can meaningfully buffer the impacts of academic stress. Critically, our findings reveal that Brazil's current medical education system inadvertently concentrates vulnerable student populations in under-resourced public institutions, suggesting that achieving educational equity requires substantial infrastructure investment and resource reallocation rather than access expansion alone. The latent class analysis identifying only 13.6% of students in high-functioning profiles underscores the urgent need for systemic reform targeting the 53.7% classified as high-risk. Future research should prioritize longitudinal designs to establish temporal relationships between institutional factors and mental health trajectories, implement randomized controlled trials of time management interventions and learning environment enhancements, and develop machine learning-based early detection systems capable of identifying at-risk students before clinical symptoms emerge. Policy recommendations include establishing minimum learning environment standards across institutions, implementing structured mentoring programs, and developing integrated mental

BJP PRE-PROOF

health screening protocols as standard components of medical education quality assurance. The ultimate goal must be transforming medical education from a system that inadvertently damages student wellbeing into one that actively promotes resilience and professional development while maintaining academic rigor.

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BJP PRE-PROOF

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BJP PRE-PROOF

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BJP PRE-PROOF

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