

Exploring How Financial and Nutritional Status Influence Students' Mental Health and Academic Performance: Evidence from the HDDS and PHQ-9 Scales

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Abstract

Mental health disorders and academic underperformance among university students represent an escalating global public health concern, particularly in low- and middle-income countries where financial hardship and dietary inadequacy converge to amplify psychological distress. This study aims to assess the prevalence of financial vulnerability, dietary diversity, and psychological distress among Bangladeshi university students, and to examine how these factors jointly shape mental health and academic performance. A cross-sectional survey of 400 undergraduates was conducted in March-2026 across four public universities in northern Bangladesh using multistage stratified random sampling, with measurement through an eight-item Financial Vulnerability Index (FVI), the twelve-group Household Dietary Diversity Score (HDDS), the nine-item Patient Health Questionnaire (PHQ-9), and self-reported Cumulative Grade Point Average (CGPA). Ordered probit regression modelled PHQ-9 severity and ordinary least squares regression with heteroskedasticity-robust standard errors modelled CGPA, both adjusted for sociodemographic and behavioral covariates. The study reveals that 48.8% of students screened positive for probable major depressive disorder. Financial vulnerability significantly elevated depression severity ($\beta = +0.046$, $p = 0.006$), while dietary diversity exerted a protective effect ($\beta = -0.102$, $p = 0.008$). Mental health substantially depressed academic performance ($\beta = -0.0949$, $p < 0.001$); financial vulnerability ($\beta = -0.0189$, $p < 0.001$) and dietary diversity ($\beta = +0.0308$, $p = 0.003$) retained significant direct effects on CGPA after adjustment for mental health. Policy responses should combine need-based financial assistance, university food service reform, and embedded mental health screening, coordinated across financial aid, health, and food services using the FVI and HDDS as low-burden screening instruments.

1. INTRODUCTION

Mental health disorders among university students have emerged as a global public health concern of escalating urgency. Entry into higher education coincides with sustained academic pressure, financial strain, social reconfiguration, and lifestyle disruption, conditions that collectively heighten susceptibility to psychiatric morbidity. Drawing on the WHO World Mental Health Surveys across eight countries, Auerbach et al. (2018) reported that approximately 35% of incoming university students met diagnostic criteria for at least one mental disorder, with major depressive disorder the most prevalent condition. Ibrahim et al. (2013) confirmed depression prevalence rates of 10%–40% across university settings in a systematic review of 24 studies, while Beiter et al. (2015) demonstrated that depression, anxiety, and academic stress are mutually reinforcing stressors that substantially impair students' functioning and long-term socioeconomic productivity.

Financial hardship is among the most robust and consistently identified predictors of psychological distress in student populations. Hammen, (2005) stress-sensitization framework posits that chronic economic strain progressively depletes coping resources and elevates vulnerability to depressive episodes over time. Existing literature has revealed a strong, dose-dependent association between financial difficulty and poor mental health: Richardson et al. (2013), in a meta-analysis of 65 studies,

found that individuals carrying unsecured personal debt were two to three times more likely to experience clinically significant depression or anxiety. A subsequent longitudinal investigation by Richardson et al. (2017) confirmed that persistent financial difficulties independently predicted deteriorating mental health trajectories among undergraduate students, even after adjusting for baseline psychological status. Lund et al. (2018), in a systematic review of reviews, extended this evidence to low- and middle-income country (LMIC) contexts, identifying poverty-related exposures, including food insecurity and income instability, as fundamental social determinants of mental disorder.

Nutritional adequacy represents an equally important, yet comparatively underexplored, determinant of student mental health. Existing literature has revealed that dietary quality exerts direct influence over neurotransmitter biosynthesis, gut-brain axis signaling, and systemic neuroinflammation, biological pathways that collectively modulate affective resilience (Sarris et al., 2015a; Slyepchenko et al., 2016). Jacka et al. (2010) demonstrated that Western dietary patterns were significantly associated with elevated odds of depression in women, while Quirk et al. (2013), synthesizing 21 observational studies, established that lower diet quality was consistently linked to higher rates of common mental disorders. A meta-analysis of 41 cohort studies by Lassale et al. (2019) quantified this effect, finding that high-quality diets conferred a 24% reduction in depression risk. Compelling causal evidence was subsequently provided by the SMILES randomized controlled trial (Jacka et al., 2017a), in which structured dietary improvement produced significantly greater reductions in depressive symptoms than social support alone. Dietary diversity, operationalized through the Household Dietary Diversity Score (HDDS), a validated 12-food-group proxy for micronutrient adequacy (Kennedy et al., 2007a) – offers a practical, scalable tool for assessing nutritional status in field settings. Existing literature has documented pervasive dietary inadequacy among students across 27 LMICs (Capitanio et al., 2020a), driven principally by budgetary constraints, with direct implications for psychological wellbeing.

Mental health, in turn, exerts a well-documented negative influence on academic performance. Hysenbegasi et al. (2005) estimated that depression was associated with a 0.49-grade-point GPA reduction, while Eisenberg et al. (2009) demonstrated that depressed students were substantially more likely to experience coursework difficulties and academic withdrawal. These effects are mediated through depression's disruption of executive function, sustained attention, and episodic memory consolidation – cognitive capacities fundamental to academic performance (Gotlib & Joormann, 2010). Grøtan et al. (2019) confirmed, in a nationally representative cohort, that depression severity was independently and inversely associated with academic self-efficacy and study progress across undergraduate disciplines.

Within Bangladesh, clinical depression prevalence of 33%–55% has been documented among university students (Islam et al., 2020a; Gaur et al., 2025) – rates substantially exceeding global averages – and depressive symptoms have been significantly associated with suicidal ideation in this population (Rasheduzzaman et al., 2022). Despite this burden, no published study has simultaneously examined financial vulnerability, dietary diversity as captured by the HDDS, and their integrated effects on both mental health and academic performance within a single empirical framework. This gap critically

constrains the development of evidence-based student welfare policy. Against this backdrop, the present study aims to assess the prevalence of financial vulnerability, dietary diversity, and psychological distress among Bangladeshi university students, and to examine how these factors jointly shape mental health outcomes and academic performance.

2. CONCEPTUAL FRAMEWORK

Drawing on the stress-sensitization model (Hammen, 2005), social determinants of mental health theory (Lund et al., 2018a), and nutritional psychiatry (Sarris et al., 2015a), this study proposes a multi-pathway framework linking financial vulnerability and dietary diversity to students' mental health status and academic performance.

Financial vulnerability (FVI) is theorized to deteriorate mental health by generating chronic psychological stress that progressively depletes students' coping resources H_1 (Richardson et al., 2013a). Dietary diversity (HDDS) is expected to exert a protective effect on mental health through supporting the micronutrient substrates required for neurotransmitter synthesis and gut-brain axis integrity H_2 (Jacka et al., 2017a; Lassale et al., 2019a). Mental health status, in turn, is theorized to negatively influence academic performance H_3 (Hysenbegasi et al., 2005a; Eisenberg et al., 2009a). Beyond this mediated pathway, financial vulnerability (H_4) and dietary diversity (H_5) are also expected to exert direct independent effects on students' cumulative GPA, reflecting resource constraints and cognitive capacity deficits that operate independently of depressive symptomatology. Sociodemographic and behavioral characteristics are incorporated as control variables across both analytical models. Figure 1 illustrates the proposed framework.

3. METHODS AND MATERIALS

3.1 Study Design

A cross-sectional survey design was employed to assess the prevalence of financial vulnerability, dietary diversity, and depression among northern Bangladeshi public university students, and to examine their associations with mental health status and academic performance at a single point in time. Cross-sectional designs are well-suited to estimating population prevalence and testing associations between exposures and outcomes efficiently within a defined sampling frame, and are widely applied in student health research internationally (Setia, 2016). Data were collected through structured, self-administered questionnaires administered in person during regular class hours, following institutional ethical clearance and prior informed consent.

3.2 Study Area and Target Population

The study was conducted across four public universities (A, B, C, and D) in northern Bangladesh, purposively selected because their student populations more closely reflect the financial and nutritional conditions central to the analytical framework: the majority originate from rural, lower- and middle-

income households and depend predominantly on irregular family financial transfers. To preserve institutional confidentiality, the universities are referred to as University A, University B, University C, and University D. The target population comprised undergraduate students enrolled in their second, third, and fourth academic years. First-year students were excluded to ensure sufficient exposure to the economic, dietary, and academic stressors under study, and to allow reporting of a meaningful cumulative academic record at data collection.

3.3 Sampling Strategy and Sample Size

A multistage stratified random sampling procedure was adopted. In stage one, four public universities were purposively selected for geographic and institutional diversity. In stage two, academic year (second, third, or fourth) served as the stratification variable. In stage three, eligible students within each stratum were selected by simple random sampling using faculty enrolment registers. Equal allocation of 100 participants per university yielded a total sample of 400 in March-2026.

The minimum required sample size was determined using (Cochran, 1977) formula for estimating proportions in large populations:

$$n = \frac{Z^2 p(1 - p)}{d^2}$$

where $Z = 1.96$ (95% confidence level), $p = 0.50$ (maximum variance assumption), and $d = 0.05$ (5% margin of error), yielding a minimum of 384. The sample was inflated to 400 to accommodate anticipated non-response and improve regression model power.

3.4 Measurement Instruments

3.4.1 Financial Vulnerability Index

Financial vulnerability was measured using a purpose-built eight-item Financial Vulnerability Index (FVI) capturing the multidimensional economic strain experienced over the preceding six months across: (i) worry about meeting financial obligations; (ii) inability to afford adequate food; (iii) difficulty covering transport and communication costs; (iv) inability to purchase academic materials; (v) deferral of tuition payments; (vi) financial stress impairing class concentration; (vii) borrowing from peers or family; and (viii) skipping meals due to insufficient funds. Each item was rated on a five-point Likert scale (1 = 'never' to 5 = 'always'), yielding a composite FVI score of 8–40; higher scores indicate greater financial vulnerability. Internal consistency was evaluated via Cronbach's α prior to regression analyses.

3.4.2 Household Dietary Diversity Score

Dietary diversity was assessed using the Household Dietary Diversity Score (HDDS), a validated indicator of household food access and micronutrient adequacy operationalized via a standard 24-hour dietary recall (Kennedy et al., 2007b). Participants reported consumption from twelve food groups: cereals and grains; roots and tubers; vegetables; fruits; meat and poultry; eggs; fish and seafood; legumes, nuts, and

seeds; milk and dairy; oils and fats; sweets; and spices and condiments. Each consumed group was scored 1 (non-consumed: 0), yielding a composite HDDS of 0–12. Dietary diversity was classified as low (0–3), moderate (4–5), or high (6–12) following established thresholds.

3.4.3 Patient Health Questionnaire-9

Psychological distress was measured using the PHQ-9, a rigorously validated nine-item self-report instrument assessing depressive symptom frequency over the preceding two weeks (Kroenke et al., 2001). Each item is rated 0–3, yielding a total score of 0–27, categorized as: minimal or no depression (0–4), mild (5–9), moderate (10–14), moderately severe (15–19), and severe (20–27). A score of ≥ 10 served as the threshold for probable major depressive disorder, consistent with standard clinical convention. The PHQ-9 has been validated for use in Bangladeshi adult populations (Islam et al., 2020b).

3.4.4 Academic Performance

Academic performance was operationalized as the student's self-reported Cumulative Grade Point Average (CGPA) on a 4.0 scale, the standardized grading convention across Bangladesh's public university sector and a well-established indicator of cumulative academic achievement in cross-sectional student research (Grøtan et al., 2019b).

3.5 Control Variables

To isolate the independent effects of FVI and HDDS on mental health and academic outcomes, both regression models incorporated a comprehensive set of sociodemographic and behavioral covariates: age (years); gender; academic year; residential origin (rural/urban); accommodation type (university hall, rented, or family); highest parental education level; daily study hours; sleep duration per night; and frequency of physical activity (≥ 30 minutes) in the preceding 30 days. These covariates were selected on theoretical grounds and their documented empirical associations with mental health and academic performance.

3.6 Statistical Analysis and Regression Models

Descriptive statistics (frequencies, proportions, means, standard deviations) were computed for all variables. Bivariate associations between categorical variables were examined using Pearson chi-square tests; Pearson correlation coefficients were calculated for continuous variables. Cronbach's α assessed FVI internal consistency ($\alpha \geq 0.70$ acceptable). Variance inflation factors (VIF) were computed to screen for multicollinearity (VIF > 10 indicative of problematic collinearity). Statistical significance was set at $\alpha = 0.05$; associations significant at $p < 0.10$ are additionally reported as marginally significant.

3.6.1 Model 1 – Ordered Probit Regression (Mental Health Status)

Mental health status (MHS), operationalized as the five-category ordered PHQ-9 severity variable, was modelled using ordered probit regression. The ordered probit specification is appropriate for ordinal

dependent variables: it correctly accounts for rank ordering of response categories without imposing the cardinal distance assumptions of OLS, and is estimated via maximum likelihood with a set of estimated threshold parameters $\mu_1 < \mu_2 < \mu_3 < \mu_4$ (Long, 1997; Greene, 2018). The latent continuous variable MHS_i^* is specified as:

$$MHS_i^* = \beta_0 + \beta_1FVI_i + \beta_2HDDS_i + \beta_3AR_i + \beta_4'X_i + \epsilon_i$$

Observed: $MHS_i = k$ if $\mu_{k-1} < MHS_i^* \leq \mu_k$, for $k = 0, 1, 2, 3, 4$

where MHS_i^* is the latent depression severity for student i ; FVI_i is the Financial Vulnerability Index score; $HDDS_i$ is the Household Dietary Diversity Score; AR_i (Academic Result) is the CGPA; X_i is the vector of control variables; ϵ_i is the standard normal error term; and μ_k are the estimated cut-point thresholds separating adjacent PHQ-9 severity categories. Average marginal effects were computed post-estimation to express the substantive impact of each predictor in interpretable probability units.

3.6.2 Model 2 – Ordinary Least Squares Regression (Academic Performance)

Academic performance (CGPA), a continuous outcome on the 0–4.0 scale, was modelled using ordinary least squares (OLS) regression. FVI , $HDDS$, and MHS were entered simultaneously alongside the full control variable vector, enabling estimation of the direct effects of financial vulnerability and dietary diversity on CGPA net of their indirect effects mediated through mental health. Heteroskedasticity-robust standard errors were applied throughout.

$$AR_i = \beta_0 + \beta_1FVI_i + \beta_2HDDS_i + \beta_3MHS_i + \beta_4'X_i + u_i$$

where AR_i is the CGPA of student i ; MHS_i is the PHQ-9 categorical severity score (entered as an ordered numeric predictor); FVI_i and $HDDS_i$ are as defined above; X_i is the control variable vector; and u_i is the robust error term. The coefficients β_1 – β_3 capture the direct effects of financial vulnerability, dietary diversity, and mental health status on academic performance, respectively, holding all other predictors constant.

Table 1
Summary of research hypotheses and corresponding model pathways

H	Hypothesis	Pathway	Model
H ₁	Higher FVI → worse mental health status (PHQ-9)	FVI → MHS	Model 1 (β ₁)
H ₂	Higher HDDS → better mental health status	HDDS → MHS	Model 1 (β ₂)
H ₃	Worse MHS → lower academic performance (CGPA)	MHS → AR	Model 2 (β ₃)
H ₄	Higher FVI → lower CGPA (direct effect)	FVI → AR	Model 2 (β ₁)
H ₅	Higher HDDS → higher CGPA (direct effect)	HDDS → AR	Model 2 (β ₂)

4. RESULTS

4.1 Sample Characteristics

A total of 400 undergraduate students were surveyed, with equal allocation of 100 respondents from each of the four sampled public universities. The mean age was 21.49 years (SD = 1.12; range 19–24), with respondents distributed across the second, third, and fourth academic years at 34.0%, 32.8%, and 33.2%, respectively. Males comprised 56.0% of the sample (n = 224) and females 44.0% (n = 176). The overwhelming majority were unmarried (95.5%), consistent with the undergraduate target population.

In keeping with the demographic profile of public university student bodies in Bangladesh, 65.8% of respondents identified a rural locality as their permanent home, while 34.2% reported urban origins. Residential arrangements were dominated by university-hall accommodation (64.5%), followed by rented mess or flat accommodation (22.2%) and family-based residence (13.2%). Parental education was modal at the Secondary (SSC) level (30.2%), with 15.2% reporting no formal schooling and 14.8% reporting graduate-level qualifications. Mean household size was 5.16 persons (SD = 1.40), reflecting the moderately large family structures characteristic of the sampling frame. Self-reported cumulative grade point average across the sample averaged 3.10 (SD = 0.44; range 1.71–4.00), centered within the standard 0–4 scale and indicative of moderate academic standing across the cohort.

4.2 Prevalence of Financial Vulnerability, Dietary Diversity, and Psychological Distress

4.2.1 Financial vulnerability

On the eight-item FVI (theoretical range 8–40), the sample mean was 21.63 (SD = 5.52; observed range 9–37). Categorical classification placed 31.0% of respondents in the low-vulnerability tier (FVI ≤ 18), 56.5% in the moderate-vulnerability band (19–28), and 12.5% in the high-vulnerability tier (≥ 29). Item-level inspection showed that worry about financial situation (FVI1, mean = 3.05) and financial interference with classroom concentration (FVI6, mean = 2.86) were the most frequently endorsed strains, while skipping meals due to insufficient funds (FVI8, mean = 2.37) and deferral of tuition payments (FVI5, mean = 2.41) were comparatively less common but reported as recurrent by a non-trivial minority.

4.2.2 Dietary diversity

The mean Household Dietary Diversity Score was 7.67 (SD = 2.27; range 2–12). Classified against the standard thresholds, 81.0% of respondents fell into the high-diversity band (HDDS 6–12), 17.0% into the moderate band (4–5), and 2.0% into the low band (0–3). Per-group consumption analysis revealed near-universal intake of cereals/grains (97.0%) and oils/fats (94.8%), and high intake of spices and beverages (87.2%) and vegetables (78.8%). By contrast, meat/poultry (38.8%), milk/dairy (42.2%), and fruits (46.2%)

were consumed by under half of respondents in the preceding 24 hours, indicating concentrated gaps in the high-cost protein and micronutrient food groups.

4.2.3 Psychological distress

PHQ-9 total scores ranged from 0 to 27 (mean = 10.22, SD = 8.07). The severity distribution was: minimal/no depression 31.5% (0–4); mild 19.8% (5–9); moderate 16.2% (10–14); moderately severe 16.5% (15–19); and severe 16.0% (20–27). Applying the standard clinical screening threshold of PHQ-9 $\geq$ 10, 48.8% of the sample screened positive for probable major depressive disorder. Endorsement of suicidal ideation (PHQ9 item 9 $\geq$ 1) was reported by 28.7% of respondents.

Table 2
Descriptive statistics for principal study variables (N = 400)

Variable	Mean / %	SD	Range	Categorical distribution
Age (years)	21.49	1.12	19–24	—
Female (%)	44.0	—	—	Male 56.0% / Female 44.0%
Rural origin (%)	65.8	—	—	Rural 65.8% / Urban 34.2%
CGPA	3.10	0.44	1.71–4.00	—
FVI	21.63	5.52	9–37	Low 31.0% / Mod 56.5% / High 12.5%
HDDS	7.67	2.27	2–12	Low 2.0% / Mod 17.0% / High 81.0%
PHQ-9 total	10.22	8.07	0–27	$\geq$ 10: 48.8%

4.3 Internal Consistency of the Financial Vulnerability Index

Internal consistency of the purpose-built FVI was excellent, with Cronbach's α = 0.900 across the eight items (n = 400). This comfortably exceeds the conventional 0.70 threshold for acceptable reliability and lies below the 0.95 ceiling above which item redundancy would be suspected, supporting the unidimensional aggregation of the eight strain indicators into a composite index for downstream regression analysis.

4.4 Bivariate Associations and Multicollinearity Diagnostics

Zero-order Pearson correlations among the principal study variables (Table 3) revealed a coherent pattern of associations consistent with the conceptual framework. Financial vulnerability correlated negatively and substantially with dietary diversity (r = -0.752, p < 0.001), positively with PHQ-9 total score (r = 0.551, p < 0.001), and negatively with CGPA (r = -0.584, p < 0.001). Dietary diversity correlated inversely with PHQ-9 (r = -0.521, p < 0.001) and positively with CGPA (r = 0.564, p < 0.001). PHQ-9 total score was strongly inversely related to CGPA (r = -0.589, p < 0.001).

Despite the strong correlation between FVI and HDDS, variance inflation factors for all predictors entered into the multivariable models remained well below the standard concern threshold of 10 (maximum VIF = 2.68, observed for FVI; mean VIF = 1.51). This indicates that the regression estimates reported below are not unduly compromised by multicollinearity.

Table 3
Pearson correlations among principal study variables

FVI	FVI	HDDS	PHQ-9	CGPA
	1.000***	-0.752***	0.551***	-0.584***
HDDS	—	1.000***	-0.521***	0.564***
PHQ-9	—	—	1.000***	-0.589***
CGPA	—	—	—	1.000***
<i>Note. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Lower triangle suppressed (symmetric matrix).</i>				

4.5 Determinants of Mental Health Status: Ordered Probit Regression

Table 4 reports coefficient estimates from the ordered probit regression of PHQ-9 severity on financial vulnerability, dietary diversity, academic performance, and the full vector of sociodemographic and behavioral controls. McFadden's pseudo- R^2 of 0.184 indicates substantively meaningful model fit for an ordered-outcome specification, and the four estimated cutpoint thresholds ($\mu_1 = -4.742$, $\mu_2 = -4.007$, $\mu_3 = -3.409$, $\mu_4 = -2.654$) were estimated with monotonic separation across the five PHQ-9 severity bands.

The Financial Vulnerability Index emerged as a statistically significant positive predictor of depression severity ($\beta = +0.046$, $SE = 0.017$, $z = +2.74$, $p = 0.006$), providing direct empirical support for Hypothesis 1. A one-unit increment on the 32-point FVI scale raises the latent depression score by 0.046 standard deviations, holding all other covariates constant. In practical terms, a student moving from low vulnerability (FVI = 15) to high vulnerability (FVI = 30) faces a 0.69-standard-deviation upward shift in latent depression — equivalent to a substantively meaningful transition across PHQ-9 severity bands.

Dietary diversity was significantly inversely associated with depression severity ($\beta = -0.102$, $SE = 0.039$, $z = -2.64$, $p = 0.008$), supporting Hypothesis 2. Each additional food group consumed in the preceding 24 hours reduced the latent depression score by 0.102 SD; a student with high dietary diversity (HDDS = 9) thus exhibited a latent depression score 0.51 SD lower than an otherwise identical student with low diversity (HDDS = 4).

Academic performance was strongly inversely related to depression severity within Model 1 ($\beta = -1.277$, $SE = 0.182$, $z = -7.00$, $p < 0.001$), confirming the tight contemporaneous coupling between academic achievement and psychological status — a finding whose directional interpretation is formally examined in Model 2 below. Among the lifestyle covariates, sleep duration ($\beta = -0.224$, $p = 0.001$) and physical

activity ($\beta = -0.145$, $p = 0.015$) were both protective against depression severity. Daily study time outside class, in contrast, showed a counterintuitive positive association with depression ($\beta = +0.155$, $p = 0.013$), plausibly reflecting the academic-pressure dimension that long study hours capture in a cross-sectional sample of high-strain students. Sociodemographic controls (age, gender, year, rural origin, residence type, parental education) did not reach statistical significance in this model.

Average marginal effects derived from Model 1 (Table 5) translate these coefficients into category-specific probability shifts. A one-unit increase in FVI reduced the probability of falling in the minimal/no-depression category by 1.16 percentage points and raised the probability of severe depression by 0.79 percentage points, on average. Conversely, each additional HDDS food group raised the probability of minimal/no depression by 2.58 percentage points and reduced the probability of severe depression by 1.77 percentage points. The directional symmetry of these category-specific effects substantiates the interpretation of FVI and HDDS as acting on the latent mental health continuum rather than on isolated severity thresholds.

Table 4

Ordered probit regression of PHQ-9 severity on FVI, HDDS, CGPA, and controls (Model 1; N = 400)

Predictor	β	SE	z	p
Financial Vulnerability Index (FVI)	0.0459**	0.0168	2.738	0.006
Household Dietary Diversity Score (HDDS)	-0.1024**	0.0388	-2.641	0.008
CGPA (academic performance)	-1.2766***	0.1824	-6.999	p < 0.001
Age (years)	0.0165	0.0728	0.226	0.821
Female (vs. Male)	-0.1485	0.1151	-1.290	0.197
Academic year	0.0745	0.1002	0.744	0.457
Rural home area	-0.1813	0.1213	-1.494	0.135
Residence: with family (vs. hall)	-0.0306	0.1686	-0.182	0.856
Residence: rented (vs. hall)	-0.0933	0.1404	-0.664	0.506
Parents' education	-0.0330	0.0495	-0.667	0.505
Study hours/day	0.1552*	0.0624	2.488	0.013
Sleep hours/night	-0.2241**	0.0701	-3.199	0.001
Physical activity (days)	-0.1451*	0.0600	-2.421	0.015
Cutpoint μ_1	-4.742	1.626	—	—
Cutpoint μ_2	-4.007	0.143	—	—
Cutpoint μ_3	-3.409	0.150	—	—
Cutpoint μ_4	-2.654	0.158	—	—
McFadden's pseudo- R^2	0.1840	—	—	—
Log-likelihood	-512.46	—	—	—
Note. † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001. Coefficients are ordered-probit estimates with model-based standard errors derived from the inverse Hessian.				

Table 5

Average marginal effects on the probability of each PHQ-9 severity category, by predictor (Model 1)

Predictor	Minimal/None	Mild	Moderate	Moderately severe	Severe
Financial Vulnerability Index (FVI)	-0.0116	-0.0013	0.0013	0.0037	0.0079
Household Dietary Diversity Score (HDDS)	0.0258	0.0029	-0.0028	-0.0082	-0.0177
CGPA (academic performance)	0.3217	0.0359	-0.0349	-0.1019	-0.2208
Sleep hours/night	0.0565	0.0063	-0.0061	-0.0179	-0.0388
Physical activity (days)	0.0366	0.0041	-0.0040	-0.0116	-0.0251
Study hours/day	-0.0391	-0.0044	0.0042	0.0124	0.0268
<i>Note. Cell values are average marginal effects: the average change in the probability of each PHQ-9 severity category associated with a one-unit increase in the predictor, holding other covariates at observed values.</i>					

4.6 Determinants of Academic Performance: OLS Regression

Table 6 presents the ordinary least squares regression of CGPA on FVI, HDDS, PHQ-9 severity, and the control vector, estimated with heteroskedasticity-robust (HC1) standard errors. The model explained 54.7% of the variance in academic performance (adjusted $R^2 = 0.532$; $n = 400$).

Mental health status emerged as the strongest individual predictor of academic performance. Each one-band increase in PHQ-9 severity was associated with a 0.095-point reduction in CGPA ($SE = 0.013$, $t = -7.44$, $p < 0.001$), providing direct empirical support for Hypothesis 3. Across the full severity range, a student in the severe-depression band carried, on average, a 0.38-point lower CGPA than an otherwise identical student in the minimal-depression band – a substantively large gap on the 0–4 scale and one that translates into a sharp differentiation across degree-classification boundaries in the Bangladesh public-university grading system.

Financial vulnerability exerted a statistically significant direct negative effect on CGPA over and above its indirect operation through mental health ($\beta = -0.0189$, $SE = 0.0050$, $t = -3.79$, $p < 0.001$), confirming Hypothesis 4. A 10-point increase on the FVI scale – for example, the gap between a student scoring $FVI = 15$ and one scoring $FVI = 25$ – is associated with a 0.189-point CGPA reduction net of depressive symptomatology, consistent with the operation of resource-constraint mechanisms (limited access to learning materials, fee-payment disruption, time reallocation to subsistence concerns) that bypass the mental-health pathway.

Dietary diversity demonstrated a statistically significant positive direct effect on CGPA ($\beta = +0.0308$, $SE = 0.0104$, $t = + 2.96$, $p = 0.003$), supporting Hypothesis 5. Each additional HDDS food group consumed was associated with a 0.0308-point CGPA gain independent of mental health and financial vulnerability, corresponding to a 0.154-point CGPA differential between students at the high-diversity (HDDS = 9) and low-diversity (HDDS = 4) thresholds.

Several controls also contributed meaningfully to the explained variance. Daily study time outside class displayed a strong positive gradient ($\beta = +0.0974$, $t = + 6.22$, $p < 0.001$); sleep duration was likewise protective ($\beta = +0.0565$, $t = + 3.17$, $p = 0.002$). Parental education exhibited a positive association with CGPA ($\beta = +0.0429$, $t = + 3.26$, $p = 0.001$). Female students in this sample recorded modestly lower CGPAs ($\beta = -0.0794$, $t = -2.63$, $p = 0.009$). Age, academic year, rural origin, residence type, screen time, and physical activity did not reach statistical significance once the focal predictors and other covariates were entered.

Table 6

OLS regression of CGPA on FVI, HDDS, PHQ-9 severity, and controls (Model 2; N = 400; HC1-robust SE)

Predictor	β	Robust SE	t	p
Intercept	+ 2.7174***	0.4038	+ 6.730	p < 0.001
Financial Vulnerability Index (FVI)	-0.0189***	0.0050	-3.793	p < 0.001
Household Dietary Diversity Score (HDDS)	+ 0.0308**	0.0104	+ 2.957	0.003
PHQ-9 severity (5-band ordinal)	-0.0949***	0.0128	-7.441	p < 0.001
Age (years)	+ 0.0125	0.0194	+ 0.646	0.519
Female (vs. Male)	-0.0794**	0.0302	-2.633	0.009
Academic year	+ 0.0223	0.0265	+ 0.840	0.401
Rural home area	-0.0435	0.0324	-1.340	0.181
Residence: with family (vs. hall)	-0.0259	0.0463	-0.560	0.576
Residence: rented (vs. hall)	-0.0408	0.0365	-1.120	0.263
Parents' education	+ 0.0429**	0.0132	+ 3.257	0.001
Study hours/day	+ 0.0974***	0.0157	+ 6.220	p < 0.001
Sleep hours/night	+ 0.0565**	0.0178	+ 3.172	0.002
Physical activity (days)	-0.0071	0.0152	-0.464	0.643
R^2	0.5474	—	—	—
Adjusted R^2	0.5322	—	—	—
N	400	—	—	—
Note. † p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001. HC1 (Stata-default) heteroskedasticity-robust standard errors.				

4.7 Summary of Hypothesis Testing

All five preregistered hypotheses derived from the conceptual framework were supported by the empirical analysis (Table 7). Higher financial vulnerability was associated with worse mental health (H_1 : $\beta = +0.046$, $p = 0.006$) and lower CGPA (H_4 : $\beta = -0.0189$, $p < 0.001$). Greater dietary diversity was associated with better mental health (H_2 : $\beta = -0.102$, $p = 0.008$) and higher CGPA (H_5 : $\beta = +0.0308$, $p = 0.003$). Worse mental health status was associated with reduced academic performance (H_3 : $\beta = -0.0949$, $p < 0.001$). Both regression models demonstrated adequate fit (Model 1 McFadden pseudo- $R^2 = 0.184$; Model 2 adjusted $R^2 = 0.532$) and were free of multicollinearity concerns. Taken together, these results delineate a coherent dual-pathway structure in which financial vulnerability and dietary

inadequacy depress academic performance both indirectly via mental health and directly through independent mechanisms.

Table 7
Summary of hypothesis tests

Hypothesis	Path	Model	β (p-value)	Conclusion
H ₁	FVI → MHS	Model 1	+ 0.0459 (p = 0.006)	Supported
H ₂	HDDS → MHS	Model 1	-0.1024 (p = 0.008)	Supported
H ₃	MHS → CGPA	Model 2	-0.0949 (p < 0.001)	Supported
H ₄	FVI → CGPA	Model 2	-0.0189 (p < 0.001)	Supported
H ₅	HDDS → CGPA	Model 2	+ 0.0308 (p = 0.003)	Supported

5. DISCUSSION

This study delineates a dual-pathway structure in which financial vulnerability and dietary inadequacy shape Bangladeshi students' academic performance both indirectly through mental health and directly through independent mechanisms. The positive association between financial vulnerability and depression severity ($\beta = +0.046$, $p = 0.006$) extends to the LMIC student context the dose-response gradient established by Richardson et al. (2013b), whose meta-analysis of 65 studies documented a two- to three-fold elevation in depression among individuals carrying unsecured debt, and confirmed longitudinally by Richardson et al. (2017b). This is consistent with Hammen's (2005) stress-sensitization framework and with Lund et al.'s (2018b) identification of poverty-related exposures as fundamental social determinants of mental disorder in LMICs.

The protective effect of dietary diversity on mental health ($\beta = -0.102$, $p = 0.008$) corroborates the nutritional psychiatry framework of Sarris et al. (2015b) and the 24% reduction in depression risk associated with high-quality diets quantified by Lassale et al.'s (2019b) meta-analysis of 41 cohort studies, with causal support from the SMILES randomized controlled trial (Jacka et al., 2017b). The pronounced gaps in high-cost food groups – meat/poultry (38.8%), milk/dairy (42.2%), and fruits (46.2%) – mirror the LMIC dietary patterns documented by Capitanio et al. (2020b) across 27 countries.

The inverse association between mental health severity and CGPA ($\beta = -0.0949$, $p < 0.001$) reproduces an established empirical regularity. Hysenbegasi et al. (2005b) estimated a 0.49-point GPA penalty attributable to depression; our estimate of a 0.38-point gap between severe and minimal severity bands falls in the same magnitude range, and is consistent with Eisenberg et al. (2009b) and Grøtan et al. (2019c). Our 48.8% prevalence of probable major depressive disorder sits within the 33–55% band reported by Islam et al. (2020c) and Biswas et al. (2022) for Bangladeshi students, exceeding the 35% pooled estimate from Auerbach et al. (2018b) WHO surveys.

A distinctive contribution is the isolation of significant direct effects of financial vulnerability ($\beta = -0.0189$, $p < 0.001$) and dietary diversity ($\beta = +0.0308$, $p = 0.003$) on CGPA net of mental health, indicating resource-constraint and cognitive mechanisms alongside the affective pathway. The cross-sectional design precludes causal attribution; nevertheless, the convergence with prior meta-analytic evidence strengthens the framework's policy relevance for LMIC student welfare.

6. CONCLUSION AND POLICY RECOMMENDATIONS

This study establishes a dual-pathway framework linking financial vulnerability and dietary inadequacy to the mental health and academic performance of Bangladeshi public university students. Drawing on a stratified random sample of 400 undergraduates across four public universities, the analysis demonstrates that financial vulnerability significantly elevates depression severity ($\beta = +0.046$, $p = 0.006$), while dietary diversity exerts a protective effect ($\beta = -0.102$, $p = 0.008$). Mental health, in turn, substantially depresses academic performance ($\beta = -0.0949$, $p < 0.001$), translating into a 0.38-point CGPA gap between severe and minimal severity bands. Both financial vulnerability ($\beta = -0.0189$, $p < 0.001$) and dietary diversity ($\beta = +0.0308$, $p = 0.003$) retain significant direct effects on CGPA after adjusting for mental health, indicating parallel resource-constraint and cognitive mechanisms. With 48.8% of students screening positive for probable major depressive disorder, the case for coordinated student welfare intervention is unambiguous.

The findings translate into a coherent set of policy levers for Bangladesh's public university sector. First, expansion of need-based financial assistance, means-tested stipends calibrated to FVI scores, emergency hardship grants to forestall tuition deferral, and protected work-study placements, would directly target the financial strain pathway. Second, university food service reform, particularly subsidized provision of the under-consumed high-protein and micronutrient-dense food groups (meat, dairy, fruits), offers a tractable lever for dietary inadequacy, supplemented by targeted nutritional support for high-vulnerability students. Third, routine PHQ-9 screening should be embedded in student health services with expanded on-campus counseling and stigma-reduction outreach; the protective effects of sleep and physical activity further argue for institutional investment in residential wellbeing programming. Critically, these interventions should not operate in silos: a cross-sectoral coordination mechanism using the FVI and HDDS as low-burden screening instruments would enable early identification of multiply vulnerable students. The cross-sectional design precludes causal attribution, and the four-university frame limits generalizability. Future research should employ longitudinal panel designs and randomized pilot interventions, conditional cash transfers or nutritional supplementation for high-vulnerability cohorts, to test these levers under causally identified conditions.

Declarations

Conflicts of Interest:

The authors declare that there are no conflicts of interest related to this work.

Clinical Trial Number

Not applicable.

Ethics Approval:

Ethical approval to conduct this study was obtained from the Research Ethics Committee of the Department of Economics, Pabna University of Science and Technology, Rajapur, Pabna-6600, Bangladesh (Approval No. PUST/ECON/REC/140). All methods were carried out in accordance with the ethical guidelines for social science research at Pabna University of Science and Technology.

Consent to Participate:

Informed verbal consent was obtained from all participants prior to the interviews. Participation was voluntary, and respondents were assured of anonymity and confidentiality.

Consent to Publish:

Participants consented to the publication of anonymized and aggregated data for academic purposes.

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Author Contribution

Md. Nayeem Hasan Pramanik: Conceptualization, Methodology, Formal analysis, Data curation, Writing-original draft preparation, Writing-review and editing, and overall coordination of the study. Jerin Fariha and Redwan Ahmed: Assisted with data collection and manuscript preparation.

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Data Availability:

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Figures

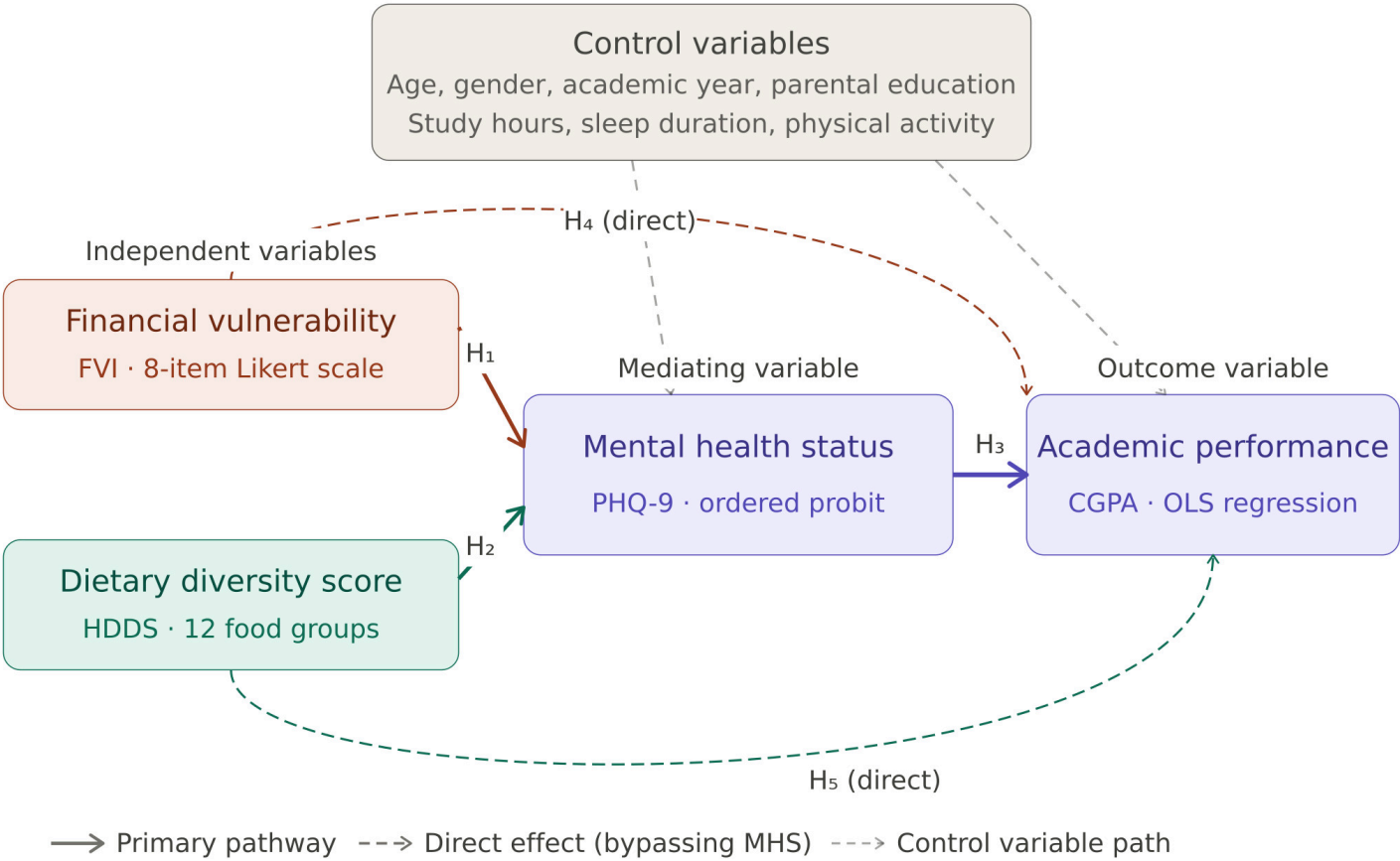


Figure 1

Conceptual Framework