# RESEARCH



# Peer learning and academic burnout mitigation in medical students: a mediation analysis

Isabel C. Gómez<sup>1</sup>, Natalia M. Jiménez<sup>2</sup>, Ana Moreira<sup>3</sup> and Legier V. Rojas<sup>4\*</sup>

## Abstract

**Background** Academic Burnout (ABO) is prevalent among medical students and is characterized by mental and physical exhaustion, cynicism, and a sense of inadequacy. Informal Peer-Assisted Learning (IPAL) is recognized as an effective strategy to enhance student wellness and mitigate ABO by fostering collaborative learning and support without direct faculty oversight. This study evaluates the effectiveness of IPAL in reducing ABO, focusing on the mediation of the observed variables and its impact on student well-being.

**Methods** This study extends previous research using Structural Equation Modeling (SEM) to include mediation analysis of the observed variables within the latent constructs of Cynicism (CY) and Inadequacy (IN) that are thought to influence the relationship between IPAL and ABO. Data were sourced from a validated Student Burnout Inventory (SBI-8) across a sample of medical students with varied IPAL engagement levels. Our approach used General Linear Model (GLM) mediation models to explore both direct and indirect effects of IPAL on ABO.

**Results** The indirect effect of IPAL on ABO is mediated through specific observed variables, including CY2 "loss of interest in academic work" ( $\beta$  = -0.092, CI, -0.174/-0.011, p = 0.027), IN1 "feeling of inadequacy" ( $\beta$  = -0.062, CI, -0.12/-0.005, p = 0.035), and IN2 "reduced academic expectations" ( $\beta$  = -0.042, CI, -0.079/-0.007, p = 0.025). The total effect of IPAL on ABO was significant ( $\beta$  = 0.170 CI, -0.326/-0.010, p = 0.034), the total indirect effect was significant ( $\beta$  = -0.197, CI, -0.338/-0.055, p = 0.006).

**Conclusions** IPAL effectively addresses critical aspects of burnout, specifically through reducing feelings of cynicism and inadequacy among medical students. These results provide a valuable framework in designing targeted interventions to reduce ABO.

Keywords Burnout, Medical students, Informal peer assisted learning, Mediation analysis

\*Correspondence:

legier.rojas@uccaribe.edu

(URP), Puerto Rico, San Juan, USA

Puerto Rico, San Juan, USA

<sup>3</sup>School of Psychology, Faculdade de Ciências e Tecnologia, Universidade Europeia, Quinta do Bom Nome, Estrada da Correia 53, Lisbon

<sup>4</sup>Department of Physiology, School of Medicine, Universidad Central del Caribe, 100 Av. Laurel, Bayamón, Puerto Rico PR. 00956, USA



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Legier V. Rojas

<sup>&</sup>lt;sup>1</sup>School of Medicine, Medical Sciences Campus, University of Puerto Rico

<sup>&</sup>lt;sup>2</sup>Department of Interdisciplinary Sciences, University of Puerto Rico (RP),

<sup>1500-210,</sup> Portugal

#### Background

Academic burnout (ABO) is a critical issue among medical students, characterized by overwhelming mental and physical exhaustion, cynicism, and a sense of inadequacy [1, 2]. This phenomenon not only affects students' mental and physical health but also impacts their academic performance, leading to adverse outcomes such as poor academic performance and increased dropout rates [3–5]. The substantial academic and emotional pressures experienced by medical students often result in heightened stress and burnout, with adverse effects that can persist into their professional lives, potentially contributing to suicidal ideation [6]. Therefore, identifying and implementing effective strategies to alleviate these effects is crucial for promoting a healthier and more sustainable educational environment.

In recent years, the role of peer-assisted learning (PAL), and more specifically informal peer-assisted learning (IPAL), has been recognized as an effective method for enhancing student wellness and mitigating ABO [7–12]. IPAL emerges organically through social networks and study groups, providing students with opportunities for collaborative learning and knowledge exchange without direct faculty oversight. This interaction not only facilitates knowledge acquisition and provides a safe space for students to share their experiences and challenges, which can be therapeutic and empowering, but also fosters the development of crucial interpersonal, social and teamwork skills, essential for success in the medical profession [7, 13–16].

Moreover, by integrating naturally into daily routines, IPAL complements formal student wellness interventions, offering a less stigmatizing and more accessible support system. Students may feel more comfortable seeking and providing support within their peer groups, leading to more sustained and effective participation. Through these informal interactions, students may experience a reduction in negative self-evaluations and a recalibration of their academic expectations, which are critical factors in the development of burnout [17–20]. The current research builds on these insights by delving deeper into the mechanisms associated with the observed variables that make educational interventions successful.

Recent studies have highlighted the influence of causal antecedent variables on outcomes of interest [21, 22]. These works emphasize the critical role of mediation mechanisms in educational interventions [23]. They demonstrate that mediating factors, such as student engagement and social support, significantly impact the success of strategies aimed at reducing symptoms of burnout, including emotional exhaustion, insomnia, and more critically, suicidal behavior among professionals [6].

This study posits that it is the participation in IPAL that mitigates ABO in medical students, rather than

a reduction in ABO driving students to participate in IPAL. Our prior work [7] established that IPAL significantly reduces ABO by primarily influencing the combined latent variables of cynicism (CY) and inadequacy (IN), without affecting exhaustion (EX). These findings, derived from statistical analysis using one-way ANOVA, lay the groundwork for this current investigation. Building on this, we hypothesize that IPAL's effectiveness in reducing ABO is mediated by specific observed variables within the latent variable's CY and IN. Thus, this study aims to identify and quantify the mediation produced by the observed variables composing these latent variables and consequently define how IPAL mitigates ABO levels.

This study examines how IPAL impacts ABO, focusing on the mediating roles of CY and IN. Cynicism is a key aspect of burnout, reflecting emotional detachment from academic work. Through IPAL, students experience social support and engagement, which may help reduce cynicism by providing a collaborative academic environment [13]. Inadequacy, another component of burnout, refers to feelings of incompetence in academic performance. Participation in IPAL may help mitigate these feelings by reinforcing students' sense of competence, as peers provide guidance and validation [9]. Therefore, we hypothesize that IPAL reduces ABO through the mediation of cynicism and inadequacy, following the assumptions proposed by the causal steps approach [24]. According to this approach: H1: the independent variable (IPAL) must have a total significant effect on the dependent variable (ABO). H2: the independent variable (IPAL) must have a significant effect on the mediating variable (Observed variables). H3: the mediating variable (Observed variables) must have a significant effect on the dependent variable (ABO) and H4: the independent variable (IPAL) must have an indirect effect on the dependent variable across the mediating variables (Observed variables) (Figure 1).

The principal focus is to answer which specific observed variables mediate the relationship between IPAL and ABO in our medical student's population? We will conduct a detailed examination of the direct and indirect impacts of IPAL on ABO, utilizing Structural Equation Modeling (SEM) to delineate the mechanisms through which IPAL exerts its effects. SEM is ideal for this research as it allows for a detailed examination of both measurement and structural models [25].

By examining these mediating relationships, we aim to uncover the underlying mechanisms fostered by a socially supportive learning environment stimulated by IPAL. This analysis will model the complex interactions between IPAL and ABO, highlighting the observed variables that mediate this relationship. Identifying these mediators will also provide a framework for practical interventions targeting behavioral and social factors to



Fig. 1 Research model. Model for the Relationship between Informal Peer-assisted Learning (IPAL), Observed Variables, and Academic Burnout (ABO). The model summarizes the hypotheses formulated in this study. This model hypothesizes that Informal Peer-assisted Learning (IPAL) directly affects Academic Burnout (ABO) (H1). Additionally, it suggests that IPAL impacts various Observed Variables (H2), which in turn influence ABO (H3). Furthermore, these Observed Variables mediate the relationship between IPAL and ABO (H4)

reduce ABO. As students engage more with their peers in informal learning settings, they may experience a reduction in negative self-evaluations and a recalibration of their academic expectations, which are critical factors in the development and exacerbation of burnout [17–20, 26]. Our study seeks to contribute to the body of knowledge on effective strategies for mitigating ABO in medical students, guiding the development of educational conditions that leverage peer support to enhance student well-being and academic success.

#### Methods

#### Study design, data collection and reporting

This study extends our previous cross-sectional study on ABO among medical students at Universidad Central del Caribe in Puerto Rico, utilizing the same participant dataset. The sample comprised 151 participants, representing 49.19% of the medical student population (n=307), indicating a confidence level greater than 90% and an error of 5%. Comprehensive details regarding the participant sample, study design, and data collection methodologies are available in our earlier publication [7].

The study employed the nine-item School Burnout Inventory (SBI-9), which was administered online to assess levels of ABO among medical students. The SBI-9 questionnaire, available in both its original English form [2] and a Spanish-adapted version [27] (refer to Supplementary Material 1 in Campillo et al. 2024 [7]) included subscales for: Exhaustion (EX) with four items, Cynicism (CY) with three items, and Inadequacy (IN) with two items. These sub-scales enable a nuanced examination of the several factors of ABO, assisting in the identification and reduction of potential confounding factors that contribute to student burnout. Participation was voluntary, with students self-reporting their gender, age range, and academic standing. The Institutional Review Board (IRB) of the UCC (Universidad Central Del Caribe) approved the method and corresponding protocols (054-2022-25-06-IRB). Overall, the information presented in this report follows recommendations presented in "A Guideline for Reporting Mediation Analysis, AGReMA" [28].

#### Validation of measurement tools

The original structure of the Student Burnout Inventory (SBI-9) [2, 27] was validated and refined to SBI-8 using Gaussian Graphical Model (GGM) analysis, Exploratory Factor Analysis (EFA), and Confirmatory Factor Analysis (CFA). These analyses were essential in confirming the psychometric properties of the SBI-8. Initial correlation analyses revealed a weak correlation with one observed variable from the EX-subscale (named EX3), resulting in its exclusion and the subsequent adoption of the SBI-8 inventory for use in further analysis. Two CFA were carried out, one-factor and two-factor, using AMOS Graphics software 29. The fit indices of the two-factor CFA were better than those of the one-factor model. Twofactor CFA of the SBI-8 Confirmatory Factor Analysis of SBI-8, showed goodness-of-fit indices suggesting a wellfit model:  $\chi^2/df$  1.59, CFI (Comparative Fit Index) 0.98, GFI (Goodness Fit Index) 0.96, TLI (Tucker-Lewis Index) 0.96, RMSEA (Root Mean Square Error of Approximation) 0.063 (0.001-0.291), SRMR (Standardized Root Mean Square Residual) 0.058. Standardized regression weights varied between 0.50 and 0.83, affirming the model's stability and relevance, evidenced by a Cronbach's alpha coefficient of 0.83. The composite reliability was tested for each dimension, obtaining a value of 0.86 for CY-IN factor and 0.75 for EX factor, with values above 0.70 (minimum considered acceptable) (Table 1) [29]. The AVE value was calculated to test convergent validity. For CY-IN, an AVE of 0.55 was obtained, and for EX, an AVE of 0.41 was obtained (Table 1). Although the AVE value for EX was less than 0.50, according to [30], as the composite reliability value is greater than 0.70, AVE values greater than 0.40 are acceptable. Finally, divergent validity was tested by calculating the square root of the AVE value, which must be greater than the correlation value between the two factors.

As seen in Table 2, the square root of the AVE value of the dimensions is higher than the correlation value between them, indicating discriminant validity.

<b>Table 1</b> Summary of the results of CFA, Construct reliability and AVE. factor weights of each item ( $\lambda$ ), their individual reliability ( $\lambda$
<sup>2)</sup> , construct reliability (CR), convergent validity (AVE value), and fit indices obtained in the confirmatory factor analysis: $\chi^2$ /df, CFI
(comparative fit index), GFI (Goodness Fit Index), TLI (Tucker-Lewis Index), RMSEA (Root Mean Square Error of Approximation), SRMR
(standardized Root Mean Square residual. The CFA was carried out using AMOS Graphics 29 software

Dimension	Item	λ	λ <sup>2</sup>	CR	AVE	χ²/gl	GFI	CFI	TLI	RMSEA	MRSR
Cynicism	CY1	0.788	0.622	0.856	0.550	1.59	0.96	0.98	0.96	0.063	0.058
	CY2	0.824	0.679								
	CY3	0.827	0.684								
	IN1	0.718	0.516								
	IN2	0.501	0.251								
Exhaustion	EX1	0.676	0.457	0.750	0.410						
	EX2	0.612	0.375								
	Ex4	0.632	0.457								

**Table 2** Discriminant validity of the dimensions. Correlation

 between the two factors and square root of the AVE values for

 each factor

	1	2
1. Exhaustion	0.640	
2. Cynicism-Inadequacy	0.479**	0.741
Note The square root values of the	AVE are shown in bold	

\*\* p<0.01

#### Independent and observed variables

The validated SBI-8 is central to this analysis, measuring three key dimensions of ABO: cynicism, inadequacy, and exhaustion, each captured by distinct observed variables. Cynicism is assessed through CY1, 'I feel a lack of motivation in my university activities, and often, I think about leaving it'; CY2, 'I feel that I am losing interest in my academic work'; and CY3, 'I constantly wonder if my academic work has any meaning'.

Inadequacy is measured through two distinct variables: IN1, 'I often have a feeling of inadequacy in my university activities', and IN2, 'I used to have higher expectations for my academic work than I do now'.

Exhaustion is assessed by EX1, 'I feel overwhelmed by academic work'; EX2 'I often find it hard to sleep because of topics related to my studies'; and EX4, 'The pressure of my university work causes me problems in my personal relationships with others'.

The questionnaire's responses were collected using a five-point Likert scale, ranging from 1 (total disagree) and 5 (total agree). Additionally, the independent variable assessing IPAL participation is: 'Although I study alone, I usually explain the concepts to my colleagues,' with response options: Frequently (F), Occasionally (O) and Never (NE). For the analysis, Frequently and Occasionally were combined into one category (O/F) to classify participants in IPAL, as this categorization did not allow for distinction based on frequency, intensity, or other dimensions of engagement.

#### Academic burnout calculations

The overall ABO was calculated using responses to the SBI-8 [31], with high ABO defined as averages above 50% per item. For graphical analyses, Likert scale values of each responder were converted into percentages. These percentages were then averaged for each item and statistically analyzed across the entire sample population.

#### **Data Analysis**

The analysis for this study was conducted using JASP 0.19.1 (Sep 09, 2024) and Jamovi 2.5.5 software [32–34]. Using General Linear Model (GLM) mediation models [35], we assessed the total impact of IPAL on ABO, thereby establishing the influence of mediation. We investigated the roles of observed variables comprising latent variables CY and IN and examined them as mediators in the relationship between IPAL and ABO. The analysis was structured to be developed to describe specific details using the observed variables [35].

To evaluate the mediation of the observed variables between IPAL and ABO, we ensured that all the assumptions proposed by Baron and Kenny (1986) [24] were fulfilled to guarantee the existence of mediation. This involved demonstrating the significance of the following: (a) the total effect of IPAL on ABO, (b) the effect of IPAL on the mediating variables, (c) the direct effect of each mediating variable on ABO, and (d) the indirect effect of IPAL on ABO through the mediating variables. Only mediating variables that met these assumptions were included in the final mediation analysis.

#### Statistical analysis

Once the normality of the variables under study has been verified, only ABO follows a normal distribution. However, as the absolute values of asymmetry and kurtosis are below 2 and 7, respectively, it can be concluded that none of the variables grossly violates normality (Table 3) [36, 37]. Because of this, path coefficients were calculated using the Standard Delta method standard errors, normal theory bootstrap under 2000 replications,

**Table 3** Results of the normality test for the variables understudy. Kolmogorov-Smirnov test statistics, degrees of freedom,significance level, asymmetry and kurtosis values for eachvariable

Variable	KS	df	р	Skewness	Kurtosis
EX	0.100***	151	< 0.001	-0.005	-0.647
CY	0.140***	151	< 0.001	0.645	-0.592
IN	0.126***	151	< 0.001	-0.212	-0.0.912
CYIN	0.091**	151	0.004	0.310	-0.728
ABO	0.054	151	0.200	0.163	-0.396
NI		~			

Note \*\* *p* < 0.01; \*\*\* *p* < 0.001

confidence interval, ML estimator, allowing to determine the strength and direction of the relationships between IPAL, the observed variables, and ABO. This method was employed to ensure precise estimations that are less sensitive to normality assumptions, enabling the generation of reliable confidence intervals and the assessment of the significance of mediation effects. Furthermore, sensitivity analyses were conducted to verify the robustness of our findings, testing various model configurations and underlying assumptions about the data.

#### **Assumption Testing and Reporting**

Critical assumptions such as the absence of multicollinearity, linearity of relationships, and homoscedasticity were rigorously tested. The results were documented in line with APA guidelines, standardized estimates ( $\beta$ ), standard deviations (SD), z-values, p-values (less than 0.05), and 95% confidence intervals (CI) to enable a comprehensive interpretation of the significance and practical implications of the findings.

#### Results

Total offects

#### **Summary of Mediation Assumption conditions**

Before reporting the results of the mediation hypotheses, we evaluated which observed variables met the necessary conditions for testing mediation as proposed by Baron and Kenny [24]. These conditions are as follows: (a) The independent variable must have a significant effect on the dependent variable; (b) The independent variable must have a significant effect on the mediating variable; (c) The mediating variable must have a significant effect on the dependent variable. Upon evaluation, it was determined that not all observed variables satisfied the necessary conditions for mediation. Specifically, CY1 (IPAL  $\diamond$  CY1,  $\beta$ =0.016, p=0.521) and CY3 (IPAL  $\diamond$  CY3,  $\beta$ =0.033, p=0.127) did not meet condition (b), which requires a significant effect from the independent variable (IPAL) on the mediating variable. Therefore, CY1 and CY3 were excluded from further mediation analysis. In contrast, CY2 (loss of interest in academic work), IN1 (feelings of inadequacy), and IN2 (diminished academic expectations) satisfied all three assumptions [24] for mediation. Consequently, the following mediation analysis will be focused on these three observed variables.

#### **Conceptual model**

The figure below shows the conceptual model used in this analysis. As an example, only CY2 was used, however, the same model applies to observed variables IN1 and IN2, which are also current mediators.

Testing the Hypotheses, the Assumption of Mediation Analysis.

**Hypothesis 1** The independent variable (IPAL) must have a total significant effect on the dependent variable (ABO).

The total effect analysis confirmed that IPAL had a significant negative effect on ABO ( $\beta = -0.170$ , p = 0.034, 95% CI [-0.326, -0.010]). This indicates that increased participation in IPAL is associated with a reduction in ABO among medical students (Table 4).

**Hypothesis 2** The independent variable (IPAL) must have a significant effect on the mediating variable (Observed variables).

The impact of IPAL on the mediating variables Cynicism (CY2), Inadequacy (IN1), and Reduced Expectations (IN2) are shown in Table 5. The results demonstrated that IPAL significantly influenced all three mediators: IPAL negatively affected CY2 ( $\beta = -0.181$ , p = 0.024, 95% CI [-0.338, -0.023]), IN1 ( $\beta = -0.177$ , p = 0.028, 95% CI [-0.332, -0.017]), and IN2 ( $\beta = -0.203$ , p = 0.011, 95% CI [-0.361, -0.047]). This confirms that participation in IPAL activities negatively affects CY2, IN1, and IN2,

**Table 4** Hypothesis 1. Total effects of Informal peer-assisted learning (IPAL) on academic burnout (ABO). . Summary of the total effects of Informal Peer-assisted Learning (IPAL) on Academic Burnout (ABO), including the 95% confidence intervals. The estimates are calculated using the Delta method standard errors, with a percentile bootstrap confidence interval and maximum likelihood (ML) estimator

							95% Confide	nce Interval
			β	Std. Error	z-value	р	Lower	Upper
IPAL	$\rightarrow$	ABO	-0.170	0.080	-2.116	0.034	-0.326	-0.010

Note Delta method standard errors, normal theory bootstrap confidence intervals, ML estimator

Path coefficients

**Table 5** Hypothesis 2. Path coefficients of Informal peer-assisted learning (IPAL) on observed variables. This table presents the path coefficients of Informal Peer-assisted Learning (IPAL) on various observed variables (CY2, IN1 and IN2) with their corresponding 95% confidence intervals

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							95% Confide	nce Interval
			β	Std. Error	z-value	р	Lower	Upper
IPAL	$\rightarrow$	CY2	-0.181	0.080	-2.260	0.024	-0.338	-0.023
IPAL	$\rightarrow$	IN1	-0.177	0.080	-2.198	0.028	-0.332	-0.017
IPAL	$\rightarrow$	IN2	-0.203	0.080	-2.554	0.011	-0.361	-0.047

Note Delta method standard errors, normal theory bootstrap confidence interval, ML estimator

**Table 6** Hypothesis 3. Path coefficients of observed variables (CY2, IN1, IN2) on academic burnout (ABO). This table presents the path coefficients of various observed variables (CY2, IN1, IN2) on Academic Burnout (ABO), along with their corresponding 95% confidence intervals

#### Path coefficients 95% Confidence Interval Std. Error ß z-value Lower Upper р CY2 ABO 0.508 0.047 10.900 < 0.001 0.419 0.602 IN1 ABO 0.354 0.046 7.632 0.446 < 0.001 0 2 6 4 IN2 ARO 0.208 0.044 4693 < 0.001 0.120 0.294

Note Delta method standard errors, normal theory bootstrap confidence interval, ML estimator

suggesting a reduction in negative feelings related to these mediators.

**Hypothesis 3** The mediating variable (Observed variables) must have a significant effect on the dependent variable (ABO).

The direct effect of the observed variables acting as mediators on ABO indicate that all three mediators showed significant positive effects on ABO (Table 6) CY2 ( $\beta$ =0.508, p<0.001, 95% CI [0.419, 0.602]), IN1 ( $\beta$ =0.354, p<0.001, 95% CI [0.264, 0.446]), and IN2 ( $\beta$ =0.208, p<0.001, 95% CI [0.120, 0.294]). These results suggest that higher levels of CY2, IN1, and IN2 contribute to increased ABO.

**Hypothesis 4** The independent variable (IPAL) must have an indirect effect on the dependent variable across the mediating variables (Observed variables).

The total indirect effects analysis showed that the mediators (Table 7) collectively had a significant indirect effect on the relationship between IPAL and ABO ( $\beta =$ -0.197, p=0.006, 95% CI [-0.338, -0.055]). Specific indirect effects were as follows: IPAL  $\rightarrow$  CY2  $\rightarrow$  ABO ( $\beta =$ -0.092, p=0.027, 95% CI [-0.174, -0.011]), IPAL  $\rightarrow$  IN1  $\rightarrow$  ABO ( $\beta =$  -0.062, p=0.035, 95% CI [-0.120, -0.005]), and IPAL  $\rightarrow$  IN2  $\rightarrow$  ABO ( $\beta =$  -0.042, p=0.025, 95% CI [-0.079, -0.007]).

#### Structural equation Model results

The path plot depicted in Fig. 2 illustrates the relationships between the independent variable (IPAL), the mediating variables (CY2, IN1, and IN2), and the dependent variable (ABO). The model presents the standardized path coefficients and their significance, highlighting the direct and indirect effects within the mediation analysis. The path coefficients show the following relationships: IPAL has a significant negative effect on (Fig. 2; Table 5), CY2 ( $\beta$  = -0.181), IN1 ( $\beta$  = -0.177), and IN2 ( $\beta$  = -0.203). The observed variables have a significant positive effect on ABO (Fig. 2; Table 6), being CY2 ( $\beta$ =0.508), IN1 ( $\beta$ =0.354), and IN2 ( $\beta$ =0.208) and the indirect paths from IPAL to ABO through (Fig. 2; Table 7) CY2 ( $\beta$  = -0.092), IN1 ( $\beta$ =-0.062), and IN2 ( $\beta$ =-0.042).

#### Impact of IPAL Engagement on ABO

Figure 3 offers a visual representation of the calculated percent of ABO and contextualizes the practical implications of our findings by examining the differences in perceptions of CY and IN among medical students based on their engagement in IPAL. The data distinctly illustrates that students who occasionally or frequently (O/F) engage in IPAL exhibit significantly lower levels of CY and IN, compared to those who never (NE) do so.

Figure 3 reveals a marked disproportion in observations: the percentage of the observed variable CY2 is notably higher among students who never (NE) engage in IPAL, displaying a statistically significant increase in CY2 (p=0.0070) compared to their O/F engaging peers. Similarly, IN2 shows a significant percent increase among students who never (NE) engage in IPAL (p=0.0434) compared to those O/F, suggesting that lack of engagement in IPAL correlates with increased feelings of inadequacy. Although IN1 also indicates a trend towards significance, it did not reach the threshold (p<0.05) in

Total indirect effects		-		ובמומרוו וא מרייהיו הריי		,			S
								95% Confiden	ce Interval
			g	Std. Error	z-value	٩		Lower	Upper
IPAL →		ABO	-0.197	0.072	-2.731	0.006		-0.338	-0.055
Indirect effects									
								195% Confiden	ce Interval
				ß	IStd. Error	Iz-value	q	ILower	lUpper
IPAL →	CY2	¢	ABO	-0.092	0.042	-2.213	0.027	-0.174	-0.011
IPAL →	IN1	¢	ABO	-0.062	0:030	-2.112	0.035	-0.120	-0.005
IPAL →	IN2	ţ	ABO	-0.042	0.019	-2.237	0.025	-0.079	-0.007

this analysis, with a p-value of 0.054, indicating a less pronounced but still noteworthy difference in engagement levels.

### Discussion

Academic burnout (ABO) is a critical issue among medical students, marked by severe mental and physical exhaustion, cynicism, and a sense of inadequacy [1, 2]. This condition adversely affects students' mental and physical health and academic performance, leading to poor outcomes and higher dropout rates [3–5]. The substantial academic and emotional demands placed on medical students can elevate stress and burnout levels. Therefore, identifying and implementing effective strategies to mitigate these effects is essential for fostering a healthier and more sustainable educational environment.

Building upon our previous findings [7], which demonstrated through ordinary one-way ANOVA that the latent variable CYIN produced a reduction in ABO among students participating in IPAL, this study employs mediation analysis to explore the underlying mechanisms of this relationship more deeply. Specifically, we aimed to examine the individual observed variables within the CYIN construct to pinpoint which specific aspects are most relevant to peer intervention. The detailed breakdown of CYIN into its observed variables (CY1, CY2, CY3, IN1, and IN2) offers targeted insights into these mechanisms.

The combined analysis of path coefficients, total and indirect effects, and percentage distributions provides a comprehensive understanding of how IPAL impacts ABO through observed variables. The significant negative indirect effects suggest that IPAL serves as a protective factor against ABO by reducing the levels of CY2, IN1, and IN2.

Our findings align with previous studies that highlight the importance of social and collaborative learning environments in mitigating burnout [10–12]. The mediation analysis demonstrates that IPAL's impact on ABO is mediated through indirect pathways involving the observed variables CY2 (loss of interest in academic work), IN1 (feelings of inadequacy), and IN2 (diminished academic expectations). These results provide evidence that IPAL influences ABO primarily through these mediating variables.

Although CY1 (lack of motivations and thoughts of leaving them) and CY3 (questioning the meaning of academic work) did not meet the mediation assumptions proposed by Baron and Kenny (1986) [24] because a significant effect from the independent variable was not found, the mediation analysis demonstrates that CY2 (loss of interest in academic work), IN1 (feelings of inadequacy), and IN2 (diminished academic expectations) significantly mediate the relationship between IPAL and ABO. This suggests that the reduction in ABO

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**Fig. 2** Structural Equation Model of Informal Peer-assisted Learning (IPAL) and Academic Burnout (ABO). Path plot. The path diagram in this figure shows the mediating action of the observed variables CY1, CY2, CY3. For statistical details see Table 4. All estimated values (β) and p-value were similar in the two analysis applications used (JASP 0.19.1). The covariance values and variance errors are shown. Delta method standard errors, percentile bootstrap confidence intervals, ML estimator



**Fig. 3** Comparison of Observed Variables (CY2, IN1, IN2) under Occasional/Frequent (O/F) and Never (NE) Conditions. This figure shows the calculated percent and their 95% CI, of CY2, IN1 and IN2. Students who often or frequently (O/F) engage in IPAL (O/F) exhibit significantly lower levels of the observed variables CY2 and IN2, compared to those who never (NE) do so. The observed variable IN1's *p-value* = 0.054. The percent and standard deviation, for CY2 O/F and NE respectively are, 31.0% (SD 30.1); 50% (SD 38.9), for IN1 O/F and NE respectively are, 51.8% (SD 29.9); 65.0 (SD 34.6); for IN2 O/F and NE respectively are, 54.8% (SD 33.1) and 69% (SD 37.7). The N value for O/F is 126 and for NE 25

is mediated through specific behavioral changes within these observed variables, rather than through direct interactions with ABO, clearly indicating that it is IPAL that acts by reducing the ABO (Fig. 2).

The present analysis reveals that the total effect of IPAL on ABO is significant and negative (Table 4), and that IPAL's influence is exerted through indirect pathways facilitated by CY2, IN1 and IN2 (Fig. 2). The significant indirect and negative effect of IPAL on ABO aligns with theoretical propositions advocating for the enhancement of peer informal interactions to prevent or reduce ABO, emphasizing the mediated nature of IPAL's impact [17, 18].

Notably, our findings highlight the role CY2, as a significant mediator in the reduction of ABO influenced by IPAL. The negative correlation between IPAL and CY2 (Table 5), coupled with a significant positive correlation between CY2 and ABO (Table 6), suggests that an increase in IPAL activities lead to a reduction in CY2, thus decreasing ABO (Table 7; Fig. 2). This indicates that engagement in IPAL activities importantly helps students reduce their disinterest in academic work, thereby enhancing their engagement [38], which in turn reduces their level of ABO. Furthermore, the observed variables within inadequacy, IN1 and IN2, emerge as significant mediators (Tables 5, 6 and 7; Fig. 2) in the reduction of ABO. IN1's and IN2's diminished expectations about academic work both highlights how peer interactions, particularly those involving teaching and support among peers, can effectively lessen feelings of inadequacy and adjust academic perceptions, reducing overall ABO.

These findings emphasize the importance of understanding and targeting specific observed variables within broader constructs to develop effective interventions. The role of peer interactions within a social context are crucial for enhancing academic collaboration and providing essential emotional and motivational support. Such interactions can help address aspects of burnout related to disinterest and detachment from academic tasks [38, 39]. Moreover, these results indicate that IPAL appears particularly effective in re-engaging students with their studies, potentially by fostering a supportive community that alleviates feelings of disengagement and reinvigorates academic enthusiasm [40].

Importantly, while the direct effect of IPAL on ABO was found to be insignificant (Fig. 2), its indirect effects through the observed variables CY2, IN1, and IN2 were statistically significant. This suggests that the reduction in ABO is mediated through specific behavioral changes encapsulated within these observed variables, rather than through direct interactions with ABO. The significant mediation obtained suggests that through these observed variables, IPAL could be particularly effective in addressing the cognitive and emotional components of burnout associated with academic self-perception. As students engage more with their peers in informal learning settings, they may experience a reduction in negative self-evaluations and a recalibration of their academic expectations, which are critical factors in the development and exacerbation of burnout [17–20, 26].

#### Limitations

Our study has several limitations. First, due to its crosssectional design, it lacks a control group, limiting our ability to make temporal comparisons concerning ABO rates and other aspects of medical students' well-being throughout their careers. Future studies should consider longitudinal designs to enable more effective comparisons over time.

Second, our study encountered limited medical student participation, with only 49.19% (151 out of 307 medical students) of medical students responding. This introduces the potential for response rate bias, which may affect the results if, for example, students experiencing higher levels of distress were either less likely or more likely to participate, due to the subject matter's pertinence. However, such patterns were not evident in our analysis.

Third, our research was conducted at a single medical school, restricting the generalizability of our findings to the broader medical student population in Puerto Rico. Future studies should include multiple institutions to enhance generalizability.

Lastly, this mediation analysis did not account for confounding factors or measurement errors that could be addressed by introducing a more detailed inventory of observed variables conforming related factors not considered in this research.

Lastly, this mediation analysis did not account for confounding factors that could influence the observed relationships. The nature of our questionnaire limited our ability to collect comprehensive psychological and personal data from the students, thus narrowing the study's overall depth. Future studies should consider exploring a broader array of factors, such as studying conditions and personal circumstances, to provide a more holistic understanding of the ABO experiences among medical students.

#### Conclusions

This study conducted a detailed analysis of the School Burnout Inventory (SBI-8) to understand how its observed variables are influenced by IPAL in mitigating ABO among medical students. Our findings reveal that out of the eight observed variables, only three—CY2 (loss of interest in academic work), IN1 (feelings of inadequacy), and IN2 (diminished academic expectations)— significantly mediate the reduction of ABO through IPAL.

These findings underscore the importance of expanding IPAL initiatives, highlighting their dual benefits in academic support and psychological well-being, thus enhancing student satisfaction and academic resilience. The specific roles of CY2, IN1, and IN2 as key mediators illustrate how cynicism and feelings of inadequacy contribute to the reduction of ABO in medical students. Consequently, interventions aimed at reducing burnout through IPAL should prioritize these elements to maximize their effectiveness.

By engaging in peer-assisted learning activities, students can lower levels of variables associated with burnout, thereby enhancing their academic well-being. The observed variables CY2, IN1, and IN2 play crucial roles in the mediation process, with CY2 and IN1 and IN2 showing significant differences between O/F and NE conditions.

Overall, the integration of structural equation modeling, path coefficients, and percentage analysis provides a solid framework for understanding the impact of IPAL on ABO. This study highlights IPAL's potential as a valuable

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tool in educational settings. Future research should explore the specific mechanisms through which IPAL influences these observed variables and identify additional factors that may help ameliorate ABO in medical students.

#### Abbreviations

ABO	Academic Burnout
AVE	Average Variance Extracted
β	Standardized Estimated
CI	Confidence Interval
CFA	Confirmatory Factor Analysis
CY	Cynicism
CY1, CY2, CY3	Observed variables 1, 2 and 3 of Cynicism
CYIN	Cynicism/Inadequacy
EX	Exhaustion
IN	Inadequacy
IN1, IN2	Observed variables 1 and 2 of Inadequacy
IPAL	Informal Peer Assisted Learning
NE	Never -IPAL
O/F	Occasionally / Frequently -IPAL
SBI-8	School Burnout Inventory – 8 items

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#### Author contributions

Project Conceptualization: ICG, LVR; Intervention Design: NJ, ICG, LVR. Supervision and Oversight: LVR; Data Curation: NJ, LVR; Data Analysis: NJ, ICG, AM, LVR. Manuscript Drafting: ICG, AM, LVR. Writing the main manuscript text: ICG, AM, LVR. Preparation of Figures: NJ, ICG, LVR. Manuscript Revisions: ICG, NJ, AM, LVR. Final Approval for Submission: ICG, NJ, LVR. All authors agree to be accountable for all aspects of the work. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis, and interpretation, or in all these areas; took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work. All authors approved the last version and agreed to be accountable for all aspects of the final product.

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#### Data availability

No datasets were generated or analysed during the current study.

#### Declarations

#### **Competing interests**

The authors declare no competing interests.

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#### References

 Dyrbye LN, Thomas MR, Shanafelt TD. Systematic review of depression, anxiety, and other indicators of psychological distress among U.S. and Canadian medical students. Acad Medicine: J Association Am Med Colleges. 2006;81(4):354–73. https://doi.org/10.1097/00001888-200604000-00009.

- Salmela-Aro K, Kiuru N, Leskinen E, Nurmi J-E. School Burnout Inventory (SBI). Eur J Psychol Assess. 2009;25(1):48–57. https://doi.org/10.1027/1015-5759.25. 1.48.
- Di Vincenzo M, Arsenio E, Della Rocca B, Rosa A, Tretola L, Toricco R, Boiano A, Catapano P, Cavaliere S, Volpicelli A, Sampogna G, Fiorillo A. Is there a burnout epidemic among medical students? Results from a systematic review. Medicina. 2024;60(4):575. https://doi.org/10.3390/medicina60040575.
- Edú-Valsania S, Laguía A, Moriano JA. Burnout: a review of theory and measurement. Int J Environ Res Public Health. 2022;19(3):1780. https://doi.org/10. 3390/ijerph19031780.
- Ilić IM, Arandjelović MŽ, Jovanović JM, Nešić MM. Relationships of workrelated psychosocial risks, stress, individual factors and burnout—questionnaire survey among emergency physicians and nurses. Med Pracy. 2017;68(2):167–78. https://doi.org/10.13075/mp.5893.00516.
- de Jesus A, Pitacho L, Moreira A. Burnout and suicidal behaviours in Health professionals in Portugal: the moderating effect of self-esteem. Int J Environ Res Public Health. 2023;20(5). https://doi.org/10.3390/ijerph20054325.
- Campillo P, de Arellano FR, Gómez IC, Jiménez N, Boada-Grau J, Rojas LV. Addressing medical student burnout through informal peer-assisted learning: a correlational analysis. BMC Med Educ. 2024;24(1):460. https://doi.org/10 .1186/s12909-024-05419-w.
- Avonts M, Bombeke K, Michels NR, Vanderveken OM, De Winter BY. How can peer teaching influence the development of medical students? A descriptive, longitudinal interview study. BMC Med Educ. 2023;23(1):861. https://doi.org/ 10.1186/s12909-023-04801-4.
- 9. de Menezes S, Premnath D. Near-peer education: a novel teaching program. Int J Med Educ. 2016;7:160–7. https://doi.org/10.5116/ijme.5738.3c28.
- Hall S, Harrison CH, Stephens J, Andrade MG, Seaby EG, Parton W, McElligott S, Myers MA, Elmansouri A, Ahn M, Parrott R, Smith CF, Border S. The benefits of being a near-peer teacher. Clin Teach. 2018;15(5):403–7. https://doi.org/10. 1111/tct.12784.
- Janzen K, Latiolais CA, Nguyen K, Dinh A, Giang D, Langas V, Davis P, Acosta WR. Impact of a near-peer teaching program within a college of pharmacy on interest in mentoring roles. Currents Pharm Teach Learn. 2023;15(4):408– 13. https://doi.org/10.1016/j.cptl.2023.04.008.
- Olaussen A, Reddy P, Irvine S, Williams B. Peer-assisted learning: time for nomenclature clarification. Med Educ Online. 2016;21(1):30974. https://doi.or g/10.3402/meo.v21.30974.
- Morris TJ, Collins S, Hart J. Informal peer-assisted learning amongst medical students: a qualitative perspective. Clin Teacher Jan. 2024;25:e13721. https:// doi.org/10.1111/tct.13721.
- Bowyer ER, Shaw SCK. Informal Near-peer teaching in Medical Education: a scoping review. Educ Health. 2021;34(1):29. https://doi.org/10.4103/efh.EfH\_2 0\_18.
- Tai-Seale M, Dillon EC, Yang Y, Nordgren R, Steinberg RL, Nauenberg T, Lee TC, Meehan A, Li J, Chan AS, Frosch DL. Physicians' well-being linked to In-Basket messages generated by Algorithms in Electronic Health Records. Health Aff. 2019;38(7):1073–8. https://doi.org/10.1377/hlthaff.2018.05509.
- Bulte C, Betts A, Garner K, Durning S. Student teaching: views of student near-peer teachers and learners. Med Teach. 2007;29(6):583–90. https://doi.or g/10.1080/01421590701583824.
- Snapp C, Bassett C, Baldwin A, Hill JR, DeBusk R. Peer-assisted learning in Undergraduate Medical Education for Resilience and Well-being. Med Sci Educ. 2023;33(1):5–6. https://doi.org/10.1007/s40670-022-01702-x.
- Worley JT, Meter DJ, Ramirez Hall A, Nishina A, Medina MA. Prospective associations between peer support, academic competence, and anxiety in college students. Soc Psychol Educ. 2023;26(4):1017–35. https://doi.org/10.10 07/s11218-023-09781-3.
- Shao Y, Kang S. The association between peer relationship and learning engagement among adolescents: the chain mediating roles of self-efficacy and academic resilience. Front Psychol. 2022;13. https://doi.org/10.3389/fpsy g.2022.938756.
- Williams CA, Vidal T, Carletti P, Rizvi A, Tolchinsky CA. Peer-assisted learning (PAL): perceptions and wellness of first-year medical students. Med Sci Educ. 2021;31(6):1911–8. https://doi.org/10.1007/s40670-021-01381-0.
- Li N, Fu L, Yang H, Zhao W, Wang X, Yan Y, Fu Y. The relationship between mobile phone dependence and academic burnout in Chinese college students: a moderated mediator model. Front Psychiatry. 2024;15:1382264. https://doi.org/10.3389/fpsyt.2024.1382264.
- 22. Chen C, Shen Y, Xiao F, Ni J, Zhu Y. The effect of smartphone dependence on learning burnout among undergraduates: the mediating effect of academic

adaptability and the moderating effect of self-efficacy. Front Psychiatry. 2023;14:1155544. https://doi.org/10.3389/fpsyt.2023.1155544.

- Coutts JJ, Hayes AF. Questions of value, questions of magnitude: an exploration and application of methods for comparing indirect effects in multiple mediator models. Behav Res Methods. 2023;55(7):3772–85. https://doi.org/10 .3758/s13428-022-01988-0.
- Baron RM, Kenny DA. The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. J Personal Soc Psychol. 1986;51(6):1173–82. https://doi.org/10.1037/0022-3514. 51.6.1173.
- Bollen KA, Stine R. Direct and Indirect effects: classical and bootstrap estimates of variability. Sociol Methodol. 1990;20:115–40. https://doi.org/10.2307 /271084.
- Simonsmeier BA, Peiffer H, Flaig M, Schneider M. Peer feedback improves students' Academic Self-Concept in Higher Education. Res High Educt. 2020;61(6):706–24. https://doi.org/10.1007/s11162-020-09591-y.
- Boada-Grau J, Merino-Tejedor E, Sánchez-García J-C, Prizmic-Kuzmica A-J, Vigil-Colet A. Adaptation and psychometric properties of the SBI-U scale for academic burnout in university students. Anales De Psicología / Annals Psychol. 2015;31(1). https://doi.org/10.6018/analesps.31.1.168581.
- Lee H, Cashin AG, Lamb SE, Hopewell S, Vansteelandt S, VanderWeele TJ, MacKinnon DP, Mansell G, Collins GS, Golub RM, McAuley JH. A Guideline for reporting mediation analyses of randomized trials and observational studies. JAMA. 2021;326(11):1045–56. https://doi.org/10.1001/jama.2021.14075.
- Marôco J. Análise De Equações Estruturais: Fundamentos teóricos, software & aplicações. 2ª edição. Pêro Pinheiro: ReportNumber, Lda. Análise De Equações Estruturais: Fundamentos teóricos. software & Aplicações - Google Livros; 2014.
- Hair J, Ringle C, Sarstedt M. PLS-SEM: indeed, a silver bullet. J Mark Theory Pract. 2011;19:139–51. https://doi.org/10.2753/MTP1069-6679190202.
- Carmona-Halty M, Mena-Chamorro P, Sepúlveda-Páez G, Ferrer-Urbina R. School burnout inventory: factorial validity, reliability, and measurement

invariance in a Chilean sample of high school students. Front Psychol. 2022;12:774703. https://doi.org/10.3389/fpsyg.2021.774703.

- The jamovi project. (2024). jamovi. (Version 2.5.5.0) [Computer Software]. Retrieved from https://www.jamovi.org
- Hayes AF. Beyond Baron and Kenny: Statistical mediation analysis in the new Millennium. Communication Monogr. 2009;76(4):408–20. https://doi.org/10.1 080/03637750903310360.
- 34. Gallucci M. (2020). jAMM: jamovi Advanced Mediation Models. [jamovi module]. Retrieved from https://jamovi-amm.github.io/
- Rosseel Y. Lavaan: an R Package for Structural equation modeling. J Stat Softw. 2012;48:1–36. https://doi.org/10.18637/jss.v048.i02.
- Finney SJ, DiStefano C. (2013). Non-normal and categorical data in structural equation modeling. In G. R. Hancock, & R. O. Mueller, editors, Structural Equation Modeling: A Second Course (2nd ed., pp. 439–492). Charlotte, NC: Information Age Publishing. https://psycnet.apa.org/record/2014-01991-011.
- Agler R, De Boeck P. On the interpretation and use of mediation: multiple perspectives on mediation analysis. Front Psychol. 2017. https://doi.org/10.33 89/fpsyg.2017.01984. 8.
- Díez J. Lack of interest? Self and peer assessment as a means to improve students' engagement. Innovations Educ Teach Int. 2023;60(2):218–26. https:/ /doi.org/10.1080/14703297.2021.2013288.
- Topping KJ. Peer education and peer counselling for health and well-being: a review of reviews. Int J Environ Res Public Health. 2022;19(10):6064. https://d oi.org/10.3390/ijerph19106064.
- Kassab SE, Al-Eraky M, El-Sayed W, Hamdy H, Schmidt H. Measurement of student engagement in health professions education: a review of literature. BMC Med Educ. 2023;23(1):354. https://doi.org/10.1186/s12909-023-04344-8.

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