

T-SNE VISUALIZATION OF MEDICAL STUDENTS' PERSONALITY TRAITS BY OVERPARENTING VS NON-OVERPARENTING BACKGROUNDS

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Abstract

Overparenting, also known as helicopter parenting, has only recently emerged as a potential barrier to the development of key psychological characteristics in emerging adults. This exploratory cross-sectional study aimed to (a) compare self-efficacy, assertiveness, and resilience between medical students raised by overparenting and non-overparenting parents; (b) examine the relationships between these psychological characteristics and parenting style; and (c) visualize personality profiles using t-distributed Stochastic Neighbor Embedding (t-SNE). A total of 200 MBBS students (100 overparented and 100 non-overparented) from a medical college were recruited. Participants were assessed using the Consolidated Helicopter Parenting Scale (CHPS), General Self-Efficacy Scale (GSES), Rathus Assertiveness Schedule (RAS), and Connor–Davidson Resilience Scale (CD-RISC). Group differences were analyzed using t-tests, correlation analyses, and multiple regression models controlling for demographic variables. K-means clustering and t-SNE were applied to explore personality profiles. Non-overparented students demonstrated significantly higher self-efficacy, assertiveness, and resilience scores than overparented students ($p < 0.001$ for all comparisons). Overparenting was a significant negative predictor of all three psychological characteristics after controlling for age, gender, and academic year ($\beta = -0.36$ to -0.45 , $p < 0.001$). Cluster analysis identified two distinct personality profiles, with non-overparented students generally exhibiting higher levels of self-efficacy, assertiveness, and resilience, as well as greater internal profile diversity and variability. The t-SNE visualization further demonstrated complete separation between the two groups based on these psychological characteristics. Overall, overparenting was negatively associated with self-efficacy, assertiveness, and resilience, three traits that are important for medical students.

Keywords: Assertiveness; Medical Students; Overparenting; Resilience; Self Efficacy

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Introduction

Parenting styles have an important influence on children's psychological development that can last a lifetime, including emotional regulation, academic performance, coping, and social skills. Increasingly, overparenting, or helicopter parenting (i.e., excessive parental control, involvement, and protection), is recognized as problematic and can stifle autonomy and psychosocial adjustment in young adults, including emerging adults in high-stress academic settings, such as medical school (Gupta et al., 2024; Urone et al., 2024).

Emerging adulthood (18–25 years) is an important developmental stage that involves identity development, increasing independence, and the development of skills to be competent in personal and professional life domains (Arnett, 2000). Medical students engage in cultivating processes emphasizing self-efficacy, assertiveness, and resilience to help bear stress, negotiate high-performance expectations, and support psychological well-being (Popa-Velea et al., 2021; Arnold et al., 2024; Chye et al., 2024). Supportive parenting shows evidence of instilling these adaptive skills while over-parenting relates to decreased autonomy, decreased self-efficacy, and increased psychological distress (Schiffrrin *et al.*, 2014; Van Ingen *et al.*, 2015). All of this aligns with self-determination theory (Deci and Ryan, 1985), which states that environments that are not autonomy supportive hinder intrinsic motivation and competence.

Despite the fact that recent studies have explored the lasting effects of overparenting on college students, there is still a gap in understanding how overparenting behavior affects integrated personality traits in medical students, particularly self-efficacy, assertiveness, and resilience (Cui et al., 2022). Moreover, previous studies have been limited to traditional correlations and failed to analyze the personality profiles that differentiate overparented individuals from non-overparented individuals.

In response to this gap, this study investigated the personality profiles of medical students with overparenting and non-overparenting parents, emphasizing self-efficacy, assertiveness, and resilience. As opposed to traditional comparisons of group means, an attempt was made to visualize natural groupings by utilizing both t-distributed Stochastic Neighbor Embedding (t-SNE) and K-means clustering, and were able to provide multidimensional insight.

The objectives of this exploratory study were: (a) to compare self-efficacy, assertiveness, and

resilience between overparented and non-overparented medical students; (b) to explore associations between overparenting scores and these factors; and (c) to employ cluster analysis and t-SNE mapping to characterize and visualize personality profiles.

Materials and Methods

Study Design

The present study utilized a cross-sectional, comparative design to examine the differences in self-efficacy, assertiveness, and resilience among medical students who had either overparenting or non-overparenting parents. Cross-sectional design was utilized as it measures variables in both groups simultaneously at a single time point which enables easier comparisons without follow-up. The exploratory nature of this study and its emphasis on identifying group differences and patterns of personality traits make cross-sectional design a feasible and methodologically appropriate choice. The cross-sectional design also facilitated the use of traditional statistical methods with advanced computer solutions-K-means cluster analysis and t-distributed Stochastic Neighbor Embedding (t-SNE) collaborations which could provide more insight into personality trait distributions within the sample.

Sample size and Participants

The study included 200 medical students, consisting of 100 overparented students and 100 non-overparented students. Students were selected using purposive sampling methods from a college to include both groups. This study included students who were currently enrolled in an MBBS program, aged between 18 and 25 years and willing to provide informed consent. Students who reported a psychiatric diagnosis or were currently taking psychiatric medication were excluded from the study to limit any conceivable effect on the psychological traits. The sample size was determined to provide adequate statistical power for detecting medium effect sizes in between-group comparisons, while also ensuring sufficient representation for cluster analysis and t-SNE visualization.

Data collection tools

a. Consolidated Helicopter Parenting Scale (CHPS) - Developed by Schiffrrin *et al.* (2019), the CHPS is a brief 10-item self-report tool designed

to capture emerging adults' perceptions of helicopter parenting, or parental overinvolvement and overcontrol. The scale was developed by consolidating items from five existing helicopter parenting measures into a single format. The items are presented with a 7 - point Likert scale; higher scores indicate higher helicopter parenting. The CHPS has demonstrated good internal consistency (Cronbach's $\alpha \approx 0.88-0.90$) and good construct validity as evidenced by significant correlations with measures of autonomy, competence, and psychological well-being.

b. General Self-Efficacy Scale (GSES) - The GSES is a 10-item scale developed by Schwarzer and Jerusalem (1995) to assess one's beliefs about their own ability to effectively deal with different types of challenging situations. Each item is rated on a 4-point Likert scale (1 = not at all true, 4 = exactly true), with higher scores indicating greater self-efficacy. The scale has demonstrated good internal reliability (Cronbach's $\alpha = 0.76-0.90$) and has shown positive correlations with optimism, adaptive coping, and job satisfaction, as well as negative correlations with depression and anxiety.

c. Rathus Assertiveness Schedule (RAS) - The RAS is a 30-item measure of socially assertive and socially unassertive behaviors developed by Rathus (1973). Respondents rate each item on a 6-point scale ranging from -3 (very uncharacteristic of me) to +3 (very characteristic of me), assessing both the frequency and comfort of assertive behavior. Internal consistency coefficients have been reported between $\alpha = 0.77$ and 0.89 , and test-retest reliability is about 0.78 . The validity of the scale is substantiated through significant associations with social competence, communication ability, and self-confidence.

d. Connor-Davidson Resilience Scale (CD-RISC) - The CD-RISC is a 25-item scale developed by Connor and Davidson (2003) to measure resilience across three domains. Each item is rated on a 5-point Likert scale from (0 = not true at all, 4 = true almost all of the time), where higher scores indicate greater resilience. The reliability study reported Cronbach's $\alpha = 0.89$. The validity is supported by significant associations with measures of hardiness, perceived stress, and mental health indicators.

Procedure

The study was ethically approved by the Meenakshi Medical College Hospital and Research Institute (MMCHRI). After receiving ethical approval for the study, participants were approached in lecture halls through institutional announcements. The study objectives, voluntary nature, and confidentiality were explained to participants before

administering the questionnaire. Prior to data collection, all participants provided written informed consent to participate in the present study. Data were collected from participants through a self-administered packet which had five sections including demographic information (age, gender, academic year), and standardized instruments. Participants completed the questionnaires in lecture halls under supervision to ensure appropriate clarification of instructions and completeness of responses. Participants were separated into two groups based on the median value of total CHPS scores (median = 47). The participant selection process and inclusion criteria are summarized in Figure 1. Participants with CHPS ≥ 47 were grouped as "Overparented" ($n = 100$), and those with CHPS < 47 as "Non-overparented" ($n = 100$). This median-split approach provided approximately equal group sizes and consistency with prior research on parenting style typologies. This dichotomous grouping was selected to facilitate interpretation and support the educational and applied purposes of this study. However, it is recognized that this dichotomous grouping minimizes the complexity of individual variability. Thus, supplementary analyses with CHPS as a continuous variable were conducted in order to verify consistency with the other findings. Overall, participants took an estimated 20-25 min to complete the study. All response data were anonymized and coded prior to analysis to maintain confidentiality.

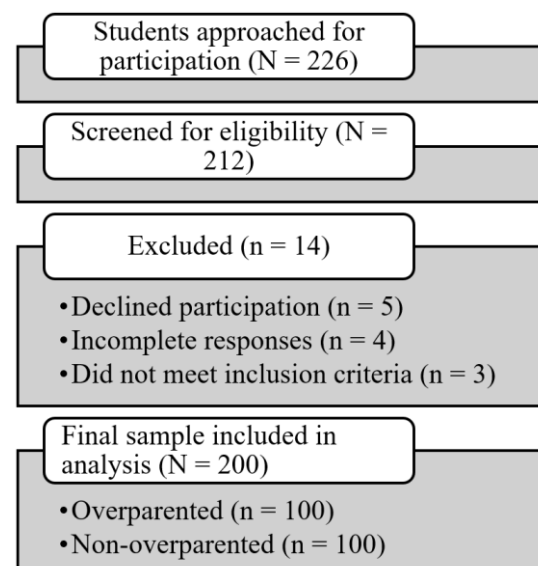


Figure 1. Participant recruitment and inclusion flowchart

Data Analysis

All data were analyzed using IBM SPSS Statistics Version 26 for basic statistical analyses and Python Version 3.9, with scikit-learn and matplotlib libraries for clustering and visualizing the results. Descriptive statistics were calculated for all variables; means and standard deviations (SD) were reported for continuous variables and frequencies with percentages for categorical variables. The internal consistency of each scale was evaluated using Cronbach's alpha coefficients. Group differences between overparented and non-overparented students were calculated through independent-samples *t*-tests for continuous variables and chi-square tests for categorical variables. The Pearson correlation coefficient was used to establish the bivariate relationships between overparenting scores and self-efficacy, assertiveness, and resilience. Multiple linear regression analyses were conducted to assess the predictive effect of helicopter parenting on each psychological trait while controlling for demographic covariates (age, gender, and year of study). To examine the robustness of these findings, supplementary multiple linear regression analyses were also performed using CHPS scores as a continuous predictor variable.

All point estimates are displayed along with 95% confidence intervals (CIs) to indicate precision. For between-group mean differences, 95% CIs using the Student's *t* distribution ($df = n_1 + n_2 - 2$) were computed. For correlations, 95% CIs were calculated via Fisher's *z*-transformation. For regression coefficients, 95% CIs were derived as $\beta \pm t \{0.975, df\} \times SE(\beta)$. Cohen's *d* effect sizes are reported with their 95% CIs.

Cluster analysis was conducted using with the K-means algorithm to determine the distinct personality profiles based on self-reported standardized self-efficacy, assertiveness, and resilience scores. The number of clusters was established using the elbow method and

silhouette scores. Identifying the multidimensional relationships between participants, *t*-distributed Stochastic Neighbor Embedding (t-SNE) was applied to the three standardized trait variables to generate two-dimensional visualizations of participant similarity. Cluster assignments were subsequently superimposed on the t-SNE projections to illustrate alignment between statistical and spatial clusters. Because t-SNE is inherently exploratory and sensitive to parameter choice and random initialization, analyses were repeated with multiple random seeds to confirm the stability of the visualization.

Results

Table 1 shows no significant differences in age ($p = 0.48$), gender ($p = 0.57$), or year of study ($p = 0.93$) between the overparented and non-overparented groups, confirming demographic comparability. The overparenting score was significantly higher in the overparented group with a large and significant difference ($M = 42.0$, $p < 0.001$), providing evidence that the classification into parenting groups is meaningful and valid.

Table 2 indicates that all three psychological trait measures—self-efficacy, assertiveness, and resilience—exhibited strong internal consistency, with Cronbach's alpha coefficients greater than 0.84 for both groups. The mean scores for each trait were consistently higher among the non-overparented students compared to overparented students, indicating that there is a consistent trend across constructs.

Table 3 shows the independent *t*-tests that reveal statistically significant differences between the two groups in all three traits ($p < 0.001$), with non-overparented students rated themselves higher than overparented students in self-efficacy, assertiveness, and resilience as illustrated in Figure 2. These differences showed a large effect

Table 1. Descriptive statistics of the demographic variables

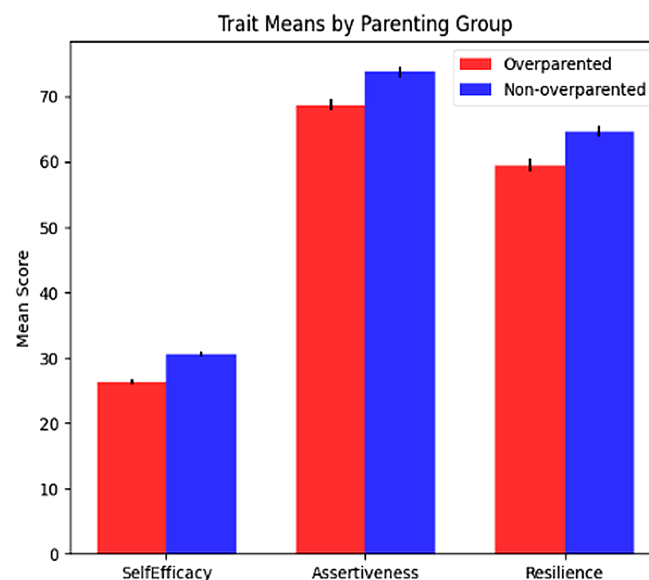
Variable	Overparented (<i>n</i> = 100)	Non-overparented (<i>n</i> = 100)	Test (<i>df</i>)	<i>p</i> -value
Age, years (mean $\pm$ SD)	22.7 $\pm$ 1.8	22.5 $\pm$ 1.9	<i>t</i> (198) = 0.71	0.48
Gender (%)				
Male	44.0	48.0	$\chi^2(1) = 0.32$	0.57
Female	56.0	52.0		
Academic year (%)				
1 st year	22.0	24.0	$\chi^2(3) = 0.45$	0.93
2 nd year	28.0	26.0		
3 rd year	30.0	32.0		
4 th year	20.0	18.0		
Overparenting score (mean $\pm$ SD)	42.0 $\pm$ 5.0	28.0 $\pm$ 6.0	<i>t</i> (198) = 17.9	<0.001

Table 2. Scale descriptives and internal consistency

Scale	Possible range	Overparented Mean±SD	Non-overparented Mean±SD	Cronbach's α
General Self-Efficacy Scale (GSES)	10–40	26.8±4.2	30.1±3.9	0.86
Rathus Assertiveness Schedule (RAS)	20–120	68.5±8.7	74.3±7.9	0.84
Connor-Davidson Resilience Scale (CD-RISC)	0–100	58.9±9.5	65.7±8.8	0.88
Consolidated Helicopter Parenting Scale (CHPS)	10-70	42.0±5.0	28.0±6.0	0.90

Table 3. Group comparisons: trait means, t-tests, and effect sizes

Trait	Overparented (mean±SD)	Non-overparented (mean±SD)	t (df)	p-value	Cohen's d (95% CI)
Self-Efficacy (GSES)	26.8±4.2	30.1±3.9	-5.68 (198)	<0.001	0.80 (0.50–1.09)
Assertiveness (RAS)	68.5±8.7	74.3±7.9	-4.77 (198)	<0.001	0.68 (0.39–0.97)
Resilience (CD-RISC)	58.9±9.5	65.7±8.8	-5.20 (198)	<0.001	0.74 (0.45–1.03)

**Figure 2. Bar chart comparing mean self-efficacy, assertiveness, and resilience across parenting groups**

(Cohen's d between 0.68 to 0.80), indicating that the differences are practically significant, not just statistically significant.

Table 4 displays the results of the multiple linear regression analyses investigating the relationships between overparenting and the three outcomes. After controlling for age, gender, and academic year, overparenting was negatively related to self-efficacy, assertiveness, and resilience ($\beta = -0.36$ to -0.45 , $p < 0.001$). The models explained 15% to 22% of the variance, with self-efficacy

showing the greatest explained variance indicating meaningful predictive utility.

To verify that this pattern was not merely a function of the dichotomous parenting score, supplementary analyses were done using the CHPS total score as a continuous predictor. As reported in Part C, higher CHPS scores (higher perceived overparenting) continued to be negatively related to self-efficacy, assertiveness, and resilience, confirming the findings from across the analytic strategies.

Table 5 shows the cluster analysis which identified three personality profiles based on the combination of self-efficacy, assertiveness, and resilience scores. The high-trait cluster is made up fully of non-overparented students (52%). The moderate-trait cluster had both groups represented. The low-trait cluster, which contained the lowest

scores in all three traits, contained mainly overparented students (47%). This pattern indicates that parenting style is strongly reflected in personality profile composition. The distinct high-, moderate-, and low-trait patterns across the clusters are illustrated in Figure 3.

Table 4. Continuous relationships: correlations and multivariable regressions

Part A - Pearson correlations (r)

Pair	r	95% CI	p-value
Overparenting ↔ Self-Efficacy	-0.46	-0.57, -0.33	<.001
Overparenting ↔ Assertiveness	-0.39	-0.51, -0.26	<.001
Overparenting ↔ Resilience	-0.42	-0.54, -0.30	<.001

Part B - Multiple linear regression (each trait regressed on overparenting, adjusted for age, gender, academic year)

Outcome	Predictor	Standardized β (Overparenting)	95% CI for β	SE	t	p	Adjusted R ² (model)
Self-Efficacy	Overparenting	-0.45	-0.59, -0.31	0.07	-6.43	<.001	0.22
Assertiveness	Overparenting	-0.36	-0.52, -0.20	0.08	-4.50	<.001	0.15
Resilience	Overparenting	-0.40	-0.54, -0.26	0.07	-5.11	<.001	0.18

Part C - Supplementary regression analysis treating CHPS as a continuous predictor.

Outcome	Predictor	Standardized β (Overparenting)	95% CI for β	SE	t	p	Adjusted R ² (model)
Self-Efficacy	Overparenting (total score)	-0.43	-0.56, -0.29	0.07	-6.01	<0.001	0.26
Assertiveness	Overparenting (total score)	-0.34	-0.49, -0.19	0.08	-4.32	<0.001	0.18
Resilience	Overparenting (total score)	-0.38	-0.52, -0.24	0.07	-5.47	<0.001	0.21

Table 5. Cluster profiles (k = 3) and distribution by parenting group

Cluster ID	Profile label (dominant pattern)	N (total)	Mean Self-Efficacy (SD)	Mean Assertiveness (SD)	Mean Resilience (SD)	Overparented n (%)	Non-overparented n (%)
1	High traits	70	32.1 (2.8)	78.9 (5.4)	72.3 (6.1)	18 (18%)	52 (52%)
2	Moderate traits	63	29.4 (2.1)	72.0 (4.2)	63.0 (5.0)	35 (35%)	28 (28%)
3	Low traits	67	24.2 (3.1)	63.1 (6.7)	54.8 (7.9)	47 (47%)	20 (20%)

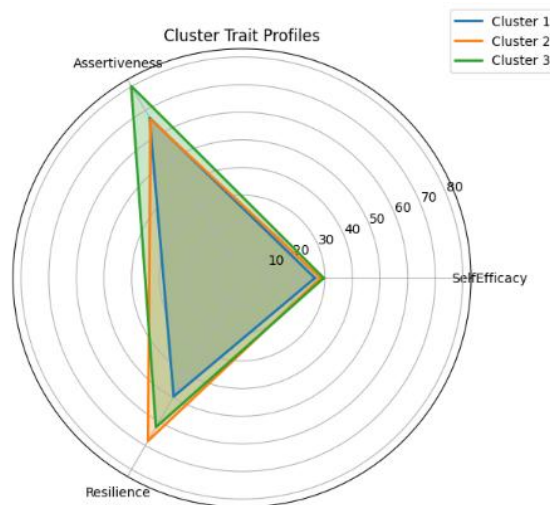


Figure 3. Radar chart showing personality trait profiles for each cluster

Figure 4 illustrates the t-distributed Stochastic Neighbor Embedding (t-SNE) projection of participants based on their standardized self-efficacy, assertiveness, and resilience scores. This t-SNE embedding two-dimensional projection accounted for about 72% of the total variance and provides a good low-dimensional representation of individual differences related to the three traits. There are two largely non-overlapping clusters representing the overparented and non-overparented students, with the overparented group being more closely clustered, which indicates lower within group variability, while the non-overparented group is more spread out, indicating more variability in combinations of traits.

Figure 5 depicts the K-means clustering overlaid on the same t-SNE projection, which also indicates three separate sub-profiles reflecting

the underlying statistical model solution. Cluster 1 (mostly non-overparented students) had high self-efficacy and resilience; Cluster 2 was composed of moderate levels across the traits; and Cluster 3 (mostly overparented students) had lower than comparative values on all three traits. The visual alignment between t-SNE structure and K-means classifications demonstrates the internal coherence of the selected profiles.

Discussion

As an exploratory investigation, the current study examined the associations between overparenting and three psychological characteristics- self-efficacy, assertiveness, and resilience- among medical students, using traditional statistical

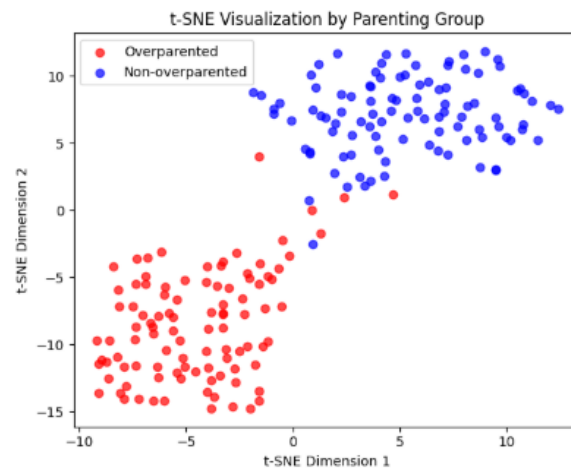


Figure 4. t-SNE plot separating overparented vs. non-overparented students

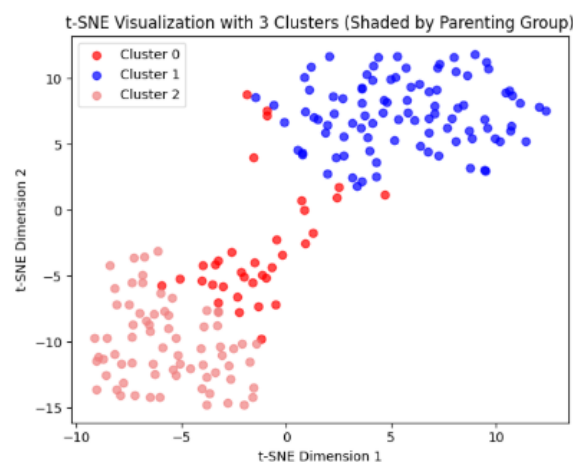


Figure 5. t-SNE plot with K-means cluster overlay

analyses, and data visualization techniques such as t-SNE clustering and K-means clustering. Across all of the analyses, and consistent patterns were identified indicating that non-overparented students scored significantly higher on all three traits, while overparented students exhibited lower scores and less internal variability. This aligns with previous research suggesting that overparenting can hinder young adults' ability to develop coping strategies independently and to build self-efficacy (Segrin *et al.*, 2012; Loton and Waters, 2017; Sanders and Morawska, 2018).

In the current study, while regression analyses revealed overparenting to be negatively related to self-efficacy, assertiveness, and resilience, the models explained approximately 15-22% of the variance in these outcomes. This indicates that there are likely other psychosocial and contextual influences contributing to the students' adaptive functioning. Potential unmeasured factors-such as coping style, perceived stress, socioeconomic background, parental education, and personality characteristics-may act as mediators or moderators influencing these associations.

Regarding self-efficacy, in accordance with earlier findings, overparented medical students had significantly lower self-efficacy scores than the non-overparented group, with overparenting remaining a significant negative correlate of self-efficacy, even after adjusting for participant age, gender, and academic year. This pattern is consistent with previous empirical literature indicating that overparenting is linked to fewer opportunities for emerging adults to develop problem-solving behaviours, engage in proactive behaviour, and learn through mastery as well as attainable failures-the critical conditions that facilitate the development of self-efficacy (Segrin *et al.*, 2012; Padilla-Walker *et al.*, 2020; Urone *et al.*, 2024). Theoretical models based on Bandura's self-efficacy theory also indicate that mastery experiences are the most potent source of efficacy development, and when parents overparent or insulate children from challenges, these mastery experiences are limited or lost. Earlier research also shows that the strength of this association may vary depending on the students' autonomy or intrinsic motivation and thus suggests possible pathways for moderation to explore further (Cui *et al.*, 2022; Jiao and Segrin, 2023; Luijk *et al.*, 2024).

A similar alignment with earlier literature emerged in relation to assertiveness. The results revealed substantially lower assertiveness among overparented students and a strong tendency for such individuals to cluster into low-assertiveness personality profiles. This outcome aligned with research that shows autonomy-supportive parenting

styles - particularly warmth, open communication, and encouragement of independent thought - tend to be associated with greater assertiveness, self-esteem, social anxiety reduction, and comfort in interpersonal boundary setting (Teuber *et al.*, 2022; Rajabi Jourshari *et al.*, 2023). Overcontrolling parenting styles, on the other hand, have been linked to reduced autonomy and assertive thinking by discouraging the expression of personal needs, overemphasising compliance, or undermining the individual's perceived right to self-advocacy. Although some studies have indicated more nuanced or contextually dependent effects- for example, with children from collectivist cultures where direct assertiveness may not be normatively reinforced, the general pattern was consistent with the observed association in this study.

Resilience, defined as the ability to adapt to stress and bounce back from adversity, was also negatively associated with overparenting, with a beta coefficient suggesting a moderate-to-strong effect. This finding aligns with several studies reporting that during higher education, emerging adults who experience higher parental control may develop fewer coping skills and decreased confidence in addressing challenges in life (Cui *et al.*, 2022; Luo *et al.*, 2024). Previous research has also identified self-confidence as a potential mediator in the parenting-resilience relationship, implying that reduced self-confidence may account, at least in part, for the reduced resilience found in overparented students. Furthermore, longitudinal research has demonstrated that individuals with lower resilience are more likely to experience mental health challenges when faced with stress, highlighting the potential implications of these associations (Mondolin *et al.*, 2024).

In addition to these analyses of individual personality traits, the cluster and t-SNE analyses identified three unique personality profiles-high, moderate, and low trait levels-defined by different combinations of self-efficacy, assertiveness, and resilience. Overparented medical students were predominantly represented in the low-trait cluster, which also exhibited limited internal variance, suggesting greater homogeneity in psychological presentation. These findings are consistent with previous research linking authoritarian or overinvolved forms of parenting to less adaptive personality profiles and narrower ranges of psychological flexibility (Emami *et al.*, 2024; Kassis *et al.*, 2025). By incorporating unsupervised machine learning approaches, this study contributes a new analytic perspective that visualizes and measures these patterns, without assuming causation.

Altogether, the findings of the present study support the growing evidence that overparenting is associated with lower levels of essential psychosocial competencies in emerging adults, especially in high-demand academic environments such as medical school. Since increased self-efficacy, resilience, and assertiveness are closely related to academic, professional success and general well-being in healthcare (Baluszek et al., 2023); interventions promoting autonomy-supportive environments and reducing overcontrolling parenting behaviours may strengthen these adaptive traits and promote student well-being.

Conclusion

In this exploratory study, it was shown that medical students who were raised by overparenting parents had significantly lower self-efficacy, assertiveness, and resilience compared to those students who were not overparented, and these differences existed even after controlling for demographics. An exploratory cluster analysis and t-SNE visualization revealed distinct personality profiles of students where those who were not overparented showed much higher scores and had greater internal variation in scores compared to students who were overparented, whose scores were lower and more homogeneous. The findings demonstrated that helicopter parenting has an independent, negative influence on psychological traits that can help promote success in the demanding medical field. However, the utilization of a cross-sectional design in this study only shows associations rather than causation. Hence, longitudinal or experimental studies should be conducted in the future for a deeper understanding of causal pathways and mechanisms through which parenting style influences students' psychological growth. These findings have significant implications for teachers, parents, and policy-makers, including the promotion of autonomy-supportive environments in medical education that can enhance students' independence in problem-solving, communication, and stress management; conducting awareness campaigns to help parents reduce overcontrolling behaviors and allow children to build confidence and resilience; and developing institutional initiatives focused on resilience training, assertiveness skills, and self-efficacy enhancement to counteract the potential adverse effects of overparenting, ultimately better preparing students for the challenges of the healthcare professions.

From both clinical and educational perspectives, these results highlight that parenting

style is an important contextual factor in students' psychological adaptation while engaged in medical training. Overparenting may impede the development of autonomy, tolerance of stress, and self-directed coping—key capacities for managing the pedagogical pressures related to health professions education. The importance of recognizing these associations can help inform preventive counseling and mentoring strategies, as well as positive frameworks for resilience within medical education institutions. These findings are increasingly valued in student support services as a contributing factor in the notice and restoration of well-being and academic functioning.

Limitations and Future Research Directions

- The cross-sectional study design limits the power to make causal inferences regarding the impact of helicopter parenting on psychological characteristics. Longitudinal studies involving following students for a few years would permit a test of whether variation in self-efficacy, assertiveness, and resilience reflects an outcome of overparenting or pre-existing personality tendencies.

- This study used self-report questionnaires, which can be subject to bias because participants may have answered in a socially acceptable way, or may not have been fully aware or accurate when reporting their behaviors, family interactions, or emotional abilities. Despite attempting to reduce these effects by using established and validated instruments and emphasizing confidentiality, there are inherent issues with self-report data, which is limited in its ability to reflect real-life behaviors or objective experiences. Therefore, the relationships observed in this study should be considered with care. Future studies should encompass observational, behavioral, or multi-informant modes of data collection to improve validity.

- All participants were intentionally selected through a purposive sample from one institution in Chennai, South India. This was done to maintain a relatively consistent academic and sociocultural context, which would minimize the variability across the institution that may confound the associations between parenting style, self-efficacy, and resilience. However, the use of purposive sampling and a single-site study might limit the generalizability and external validity of the study. Students in other institutions, disciplines, or regions may differ in their family dynamics, exposure to stressors, and institutional ecosystem. Future

research employing random or stratified sampling across multiple educational contexts and geographic regions would enhance the representativeness and generalizability of these results.

- Adopting a dichotomous typology of parenting styles can oversimplify the intricacies of variations in parenting. Although additional analyses using continuous CHPS scores were consistent with our findings, future work should use person-centered methods (e.g., latent profile analysis or latent class analysis) to investigate finer patterns of parenting influence.

- Another methodological note to mention is the implementation of the t-distributed Stochastic Neighbor Embedding (t-SNE) approach in the visualization of multivariate relationships. As a non-deterministic, unsupervised algorithm, t-SNE provides an exploratory visualization of high-dimensional data based on the specified parameters and random initialization. Thus, t-SNE figures shown in this study are more illustrative than definitive. To support robustness, all analyses were run with multiple random seeds, which exhibited stability across the runs in the overall pattern of cluster separations.

- Only three psychological characteristics have been studied in this research: self-efficacy, assertiveness, and resilience. However, there is a strong possibility for helicopter parenting to affect a larger number of personal and professional skills than these three, such as emotional intelligence, stress regulation ability, empathy, and adaptability. Broader trait inclusion would yield a more comprehensive personality profile.

- Though the sample size was adequate to understand medium-level effect sizes and to perform cluster analyses, it may have inhibited the ability to investigate smaller but important differences between subgroups. A larger sample might provide improved statistical power and support a detailed evaluation of subgroup differences.

- Many potentially important variables were not measured in the present study. Variables such as socioeconomic status, parental education, parental mental health, academic achievement, or family structure could be important influences on parenting behavior and students' psychological outcomes. The omission of these covariates may have limited the extent to which analyses were able to explain the variance, and may have contributed to the comparatively small percentage of variance explained by the regression models. Future studies that include these psychosocial and contextual variables would allow more complex modeling of the mechanisms by which overparenting influences

resilience, self-efficacy, and assertiveness among students.

- Although this study briefly discusses the possible interventions, no quasi-experimental or experimental interventions were trialed. Targeted programs like autonomy-supportive communication training for parents or student resilience workshops should be implemented and tested by future studies to determine if they would effectively resist the adverse effects.

- With the changing dynamics of parental involvement in the digital world, future research also needs to examine the role of technology-facilitated overparenting (e.g., constant texting, tracking apps) and its possible impact on the development of emerging adults.

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