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Psychobiological Mechanisms of Resilience in the *Pesantren* Ecology: A Comparative Structural Equation Modeling of Distress, Coping, and Salivary Cortisol between Boarding and Non-Boarding Santri in East Java

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A B S T R A C T

Introduction: The *Pesantren* (Islamic boarding school) represents a unique educational ecosystem in Indonesia that imposes distinct psychosocial demands on students (*Santri*). While the academic outcomes of this system are well-documented, the psychobiological divergences between boarding (*Mukim*) and non-boarding (*Kalong*) students regarding stress adaptation remain under-researched. **Methods:** This cross-sectional comparative study involved 500 adolescents (ages 15-18) from four large *Pesantrens* in East Java, stratified into Boarding (n = 250) and non-boarding (n = 250) groups. Participants completed the Kessler Psychological Distress Scale (K-10), the Connor-Davidson Resilience Scale (CD-RISC-25), and the Brief-COPE. Additionally, morning salivary cortisol samples were collected to assess hypothalamic-pituitary-adrenal (HPA) axis activity. Data were analyzed using MANCOVA and Structural Equation Modeling (SEM). **Results:** Boarding students exhibited significantly higher baseline psychological distress ($p < 0.001$) and elevated cortisol levels compared to non-boarders. However, they also demonstrated significantly higher resilience scores and utilization of adaptive religious coping strategies. SEM analysis revealed that while boarding status is a predictor of physiological stress, its impact on psychological distress is fully mediated by adaptive coping mechanisms and community integration. **Conclusion:** Boarding students face heightened physiological stress loads but possess superior compensatory resilience mechanisms driven by religious coping. Interventions should focus on strengthening these adaptive pathways.

1. Introduction

Adolescence represents a distinct and critical epoch in human development, characterized not merely by physical maturation but by a profound reorganization of the central nervous system. This period is demarcated by a heightened neurodevelopmental plasticity, specifically involving the synaptic pruning of the prefrontal cortex (PFC) and the recalibration of the limbic system.[1] Consequently, adolescents exhibit a unique sensitivity to environmental stimuli, social evaluation, and psychosocial stress. Central to this developmental trajectory is the hypothalamic-pituitary-adrenal (HPA) axis—the body's primary neuroendocrine system for stress response.[2] During adolescence, the HPA axis exhibits increased lability; basal cortisol levels and stress-induced reactivity fluctuate significantly as the brain attempts to establish adult-like homeostatic set

points. This biological volatility renders the adolescent particularly susceptible to the effects of their "social ecology." The environment in which an adolescent navigates this transition can either serve as a scaffold for robust mental health or a catalyst for psychopathology.[3] In the context of Indonesia, the most dominant and culturally significant educational ecology outside the state school system is the *Pesantren* (Islamic boarding school). For millions of Indonesian adolescents, the *Pesantren* is not just a school; it is a "total institution" that fundamentally structures their daily rhythms, social hierarchies, and cognitive frameworks during this peak window of neuroplasticity.[4]

The *Pesantren* tradition in Indonesia is centuries old, serving as a bastion of indigenous Islamic morality and education.[5] Unlike Western boarding schools, which are often associated with elitism or correctional purposes, the Pesantren is deeply rooted in the communal ethos of Javanese culture, emphasizing *Adab* (etiquette), *Akhlaq* (morality), and spiritual discipline. However, structurally, the modern *Pesantren* is often bifurcated into two distinct student populations, creating a natural experimental framework for psychiatric inquiry. The first group, the *Santri Mukim* (boarding students), reside permanently within the complex.[6] Their lives are governed by a 24-hour curriculum that blends secular education with rigorous religious training. They live in high-density dormitories, separated from parents, and are subject to the absolute authority of the *Kiai* (spiritual leader) and *Ustaz* (teachers). Their environment is closed, immersive, and intensely communal. The second group, the *Santri Kalong* (non-boarding students), attend the same classes and religious circles during the day but return to their parental homes at night. They inhabit a liminal space, navigating the "dual worlds" of the strict, sacred enclave of the Pesantren and the secular, fluid environment of the outside community and family home. While the academic and theological outcomes of these two groups have been compared extensively in educational literature, the psychiatric and physiological divergences remain largely unexplored. Does the immersion of the *Santri Mukim* protect them through "spiritual shielding," or does the separation from family and institutional rigidity impose a "biological tax" on their developing stress systems?

The daily life of a boarding *Santri* is rigorous. It involves arguably the most intense schedule of any adolescent demographic in the country.[7] Days often begin at 03:00 AM for *Tahajjud* (night vigil prayers), followed by *Subuh* (dawn prayers), Quranic memorization, formal schooling, and evening theological study circles (*Kitab Kuning*), often concluding only at 10:00 PM. From a chronobiological perspective, this schedule is a potential disruptor of circadian rhythms. Sleep deprivation and fragmented sleep architecture are well-established stressors that can dysregulate cortisol secretion, potentially leading to a state of chronic allostatic load. Furthermore, the boarding environment introduces unique psychosocial stressors. The *Santri Mukim* must navigate the lack of privacy inherent in dormitory living, the pangs of separation anxiety (homesickness), and strict disciplinary codes restricting technology and external communication. In Western literature, early boarding school placement has sometimes been associated with "Boarding School Syndrome," characterized by emotional detachment and depression. However, applying this lens uncritically to the *Pesantren* context is problematic. The *Pesantren* is infused with the cultural concept of *Riyadah*—spiritual exercise or asceticism. Hardship in the *Pesantren* is often culturally reframed not as "suffering" but as "tempering" the soul.[8]

This reframing hypothesis suggests that religious coping mechanisms may alter the physiological impact of stress. Neuroimaging studies indicate that cognitive reappraisal—a key component of religious coping—can downregulate amygdala activation, thereby dampening the HPA axis response. If *Santri Mukim* successfully internalizes this religious worldview, the physiological stress of sleep deprivation and separation might be buffered by high-level psychological resilience. Conversely, *Santri Kalong*,

who have access to parental comfort and better sleep environments, might display lower basal stress but potentially lower psychological resilience due to a lack of "steeling" experiences.

Resilience in this study is operationalized beyond the simple absence of pathology. It is viewed as a dynamic process of positive adaptation in the context of significant adversity. In the *Pesantren*, resilience is culturally coded as *Barakah* (blessing obtained through struggle) and *Sabar* (active endurance). The communal nature of the dormitory—the *Ukhuwah Islamiyah* (Islamic brotherhood/sisterhood)—also provides a dense network of peer support that is qualitatively different from the family support available to non-boarders.[9]

Existing literature posits that the "Barakah" culture acts as a salutogenic factor. However, most studies validating this are qualitative or rely solely on self-report questionnaires. Self-reports in highly religious populations are prone to social desirability bias; students may underreport distress to appear "good" or "patient" Muslims. This methodological limitation has left a critical gap in our understanding. We do not know if the *Santri* are genuinely resilient or if they are merely engaging in "spiritual bypassing"—using religious ideas to avoid facing unresolved emotional pain, which would manifest in elevated biological stress markers despite normal questionnaire scores.

To truly understand the cost and benefit of the *Pesantren* boarding system, we must look beneath the behavioral surface. This necessitates the integration of biomarkers. Salivary cortisol is an ideal non-invasive biomarker for this population. As the end-product of the HPA axis, morning cortisol levels reflect the body's anticipation of the day's demands. Elevated baseline cortisol (hypercortisolism) can indicate chronic stress exposure, while blunted cortisol (hypocortisolism) can indicate burnout or trauma response.[10] By triangulating self-reported distress (K-10), psychometric resilience (CD-RISC), and biological stress (Cortisol), we can construct a sophisticated model of adaptation. Does the boarding environment create a "tougher" student at the cost of higher physiological wear and tear? Or does the religious environment truly penetrate the biological level, lowering cortisol despite sleep restriction?

Therefore, this study aims to bridge the gap between cultural education and biological psychiatry. The primary aim of this study is to compare the psychological distress, coping mechanisms, and physiological stress markers (cortisol) between boarding (*Mukim*) and non-boarding (*Kalong*) students. The novelty of this research lies in its integration of biological markers (salivary cortisol) with advanced psychometrics (SEM) to elucidate the specific pathophysiological pathways of resilience within the ethno-religious context of East Java. Unlike previous studies that relied on subjective reports, this research offers the first objective, bio-behavioral evaluation of how the "total institution" of the Pesantren shapes the adolescent stress response system.

2. Methods

To elucidate the psychobiological impact of the *Pesantren* ecosystem, a cross-sectional comparative study design was employed. This design was selected as the most appropriate method to capture a "snapshot" of the physiological and psychological states of students actively immersed in the educational environment, allowing for immediate comparative analysis of HPA-axis activity and resilience markers. The study was conducted over a six-month period, from January to June 2024, to encompass a full academic semester, thereby avoiding the acute stress periods associated with initial enrollment or final examinations. The research setting comprised four distinct Tier-1 *Pesantrens* located in the East Java province of Indonesia. East Java was chosen as the study location as it historically serves as the heartland of the *Santri* tradition, hosting the highest density of traditional Islamic boarding schools in the archipelago. The selection of these specific institutions was driven by a rigorous standardization protocol: each selected *Pesantren* was required to have

a student population exceeding 2,000 to ensure statistical power and possessed a uniform curriculum structure that combined the National Curriculum (K-13/Merdeka) with the traditional *Salaf* (classical Islamic texts) curriculum. This uniformity was critical to control for confounding variables related to academic workload disparities or differing institutional cultures. Within these settings, the environment for the Boarding students (*Santri Mukim*) consists of high-density communal dormitories, shared by 20–30 students per room, fostering an intense collective lifestyle. Conversely, the non-boarding students (*Santri Kalong*) attend the same rigorous daily schedule but return to the privacy and familial environment of their homes each evening, creating a distinct "dual-environment" experience.

A rigorous stratified random sampling technique was utilized to recruit participants, ensuring that the sample accurately reflected the heterogeneity of the student body. The stratification was based on grade level (Classes 10, 11, and 12) to account for developmental differences in adolescence. The sample size determination was conducted a priori using G*Power 3.1 software. The calculation was based on a Multivariate Analysis of Variance (MANOVA) framework, given the study's aim to compare two groups across multiple dependent variables (cortisol, distress, resilience). Parameters were set with a medium effect size ($f2 = 0.25$), a significance level (α) of 0.05, and a high statistical power ($1-\beta$) of 0.95 to minimize Type II errors. While the calculation yielded a minimum requirement of 400 participants, the recruitment target was inflated to 550 students. This oversampling was a deliberate methodological safeguard to account for potential attrition, incomplete questionnaire responses, or insufficient saliva volume for biological assay, which are common challenges in field-based bio-behavioral research.

Strict eligibility criteria were applied to minimize biological confounding. Inclusion was limited to active students aged 15–18 years (Senior High School equivalent) who had been enrolled for at least 12 months. This 12-month tenure requirement was crucial to ensure that participants had fully acclimatized to the *Pesantren* environment, thereby measuring chronic adaptation rather than the acute stress response associated with the initial separation from parents. Exclusion criteria were strictly biological and psychiatric. Participants reporting the current use of corticosteroids (such as for asthma) or psychotropic medications were excluded, as these substances directly alter HPA-axis function. Furthermore, students with acute infections or illnesses within 7 days prior to sampling were excluded to prevent inflammation-induced cortisol spikes. Finally, to ensure that distress scores reflected the educational environment rather than external trauma, students with a history of major bereavement (such as the death of a parent) in the preceding six months were excluded. From the initial pool, the final validated dataset consisted of $N = 500$ participants, achieving a perfectly balanced distribution between the Boarding group ($n = 250$) and the non-boarding group ($n = 250$).

The study employed a battery of psychometric instruments validated for use in the Indonesian context, ensuring cultural and linguistic appropriateness. To assess general psychopathology, we utilized the Indonesian version of the Kessler Psychological Distress Scale (K-10). The K-10 serves as a global measure of non-specific psychological distress, focusing on anxiety and depressive symptoms experienced over the preceding 30 days. It comprises 10 items rated on a 5-point Likert scale ranging from 1 (none of the time) to 5 (all of the time). The scale was chosen for its high sensitivity in community screening and its ability to discriminate between cases of serious mental illness and non-cases. In the current study, the instrument demonstrated robust internal consistency (Cronbach's $\alpha = 0.89$), indicating high reliability within the *Santri* population.

Resilience was operationalized using the Connor-Davidson Resilience Scale (CD-RISC-25). Unlike scales that measure resilience merely as the absence of distress, the CD-RISC measures resilience as a distinct trait involving personal competence, trust in one's instincts, positive acceptance of change, and

spiritual influences. This 25-item instrument is particularly suitable for the *Pesantren* context as it explicitly includes items related to faith and spiritual tenacity. Scores range from 0 to 100, with higher scores indicating greater resilience. The scale showed excellent reliability in this sample (Cronbach's α = 0.92).

To understand the behavioral and cognitive strategies used by students to manage stress, the Brief-COPE Inventory was administered. This 28-item self-report questionnaire assesses a broad range of coping responses. For the purpose of this analysis, items were aggregated into three theoretical domains relevant to the study's hypothesis: (1) Problem-Focused Coping: Strategies aimed at altering the source of the stress (such as Active Coping, Planning); (2) Emotion-Focused Coping: Strategies aimed at managing emotional distress (such as Venting, seeking emotional support); (3) Religious/Adaptive Coping: Strategies involving turning to religion or spiritual reframing. This domain is of central interest given the religious curriculum of the *Pesantren*.

To provide an objective physiological correlate to the self-reported psychological data, salivary cortisol was selected as the biomarker of HPA-axis activity. Saliva collection is non-invasive and stress-free, making it superior to venipuncture for adolescent research. Samples were collected during a strictly controlled window between 07:00 and 08:00 AM. This timing was chosen to capture the post-awakening decline in cortisol, providing a measure of basal HPA-axis activity. Participants were instructed to refrain from eating, drinking (except water), smoking, or brushing their teeth for 60 minutes prior to collection to prevent sample contamination or dilution. Saliva was collected using the passive drool method into sterile, polypropylene cryovials to avoid the interference associated with cotton swabs. Immediately post-collection, samples were placed in portable coolers with ice packs (maintaining 4°C) and transported to the laboratory within 4 hours, where they were stored at -20°C until analysis. Cortisol concentrations were quantified using high-sensitivity Enzyme-Linked Immunosorbent Assay (ELISA) kits tailored for salivary analysis. The assay sensitivity was 0.1 nmol/L. To ensure precision, all samples were run in duplicate. The intra-assay and inter-assay coefficients of variation (CV) were maintained below 5% and 10%, respectively, meeting rigorous laboratory standards.

Data management and analysis were conducted using IBM SPSS Statistics version 29 for preliminary analyses and AMOS version 29 for Structural Equation Modeling. The analytical strategy proceeded in four distinct phases: (1) Descriptive and Normality Testing: Initial analyses involved descriptive statistics (means, standard deviations) and tests for normality (skewness and kurtosis). Cortisol data, which typically exhibit a skewed distribution, were log-transformed (log10) to meet the assumptions of parametric testing before analysis; (2) Comparative Analysis (MANCOVA): To test the primary hypothesis regarding group differences, a Multivariate Analysis of Covariance (MANCOVA) was executed. This sophisticated technique allowed for the simultaneous comparison of Boarding and Non-Boarding groups across three dependent variables (Distress, Resilience, and Cortisol) while statistically controlling for potential confounders: Age, Gender, and Socioeconomic Status (SES). Controlling for SES was particularly critical given the disparity in fees associated with boarding; (3) Correlation Analysis: Pearson product-moment correlations were calculated to examine the bivariate relationships between physiological arousal (cortisol) and psychological states, providing the foundation for the structural model; (3) Structural Equation Modeling (SEM): The final and most complex phase involved SEM to test the hypothesized mediation model. A path analysis was constructed to determine if Coping Mechanisms acted as a mediator between Boarding Status (predictor) and the outcomes of Distress and Resilience. Model fit was evaluated using standard indices: the Chi-square/degrees of freedom ratio ($\chi^2/df < 3.0$), the Comparative Fit Index (CFI > 0.95), the Tucker-Lewis Index (TLI > 0.95), and the

Root Mean Square Error of Approximation (RMSEA < 0.08). The significance of indirect effects (mediation) was tested using bootstrapping with 2,000 resamples to generate 95% confidence intervals.

The study adhered strictly to the ethical principles of the Declaration of Helsinki. Ethical clearance was granted by the Institutional Review Board of the CMHC Research Center, Indonesia. Given the vulnerability of the study population (minors residing in a hierarchical institution), a multi-tiered consent process was implemented. Written informed consent was obtained from parents or legal guardians, and separate written assent was obtained from the adolescents themselves. Participants were informed that their participation was voluntary, that their refusal would not impact their academic standing, and that all data—particularly biological samples—would be anonymized using alphanumeric codes. Confidentiality was strictly maintained, with no individual results shared with school authorities.

3. Results

The demographic profile presented in Table 1 elucidates the comparative baseline characteristics of the study population (N=500), revealing a high degree of homogeneity across most biological and educational parameters. Statistical analysis confirmed that the *Santri Mukim* (boarding) and *Santri Kalong* (non-boarding) cohorts were effectively balanced regarding developmental age ($p=0.654$) and gender distribution ($p=1.000$), thereby minimizing potential confounding from maturational or sex-linked biological variance. Additionally, the duration of academic enrollment showed no significant divergence ($p=0.210$), ensuring that both groups possessed comparable levels of acclimatization to the institutional culture.

Crucially, however, the analysis identified a statistically significant disparity in socioeconomic status (SES) ($p<0.05$). The boarding cohort skewed towards higher economic tiers, with 84% classifying as middle or high SES, compared to only 68% in the non-boarding group. This distributional asymmetry likely reflects the financial prerequisites of residential education. From a methodological standpoint, this finding is pivotal; it identifies SES as a distinct differentiating factor rather than a random variate. Consequently, this necessitates the rigorous application of SES as a covariate in subsequent multivariate analyses to ensure that observed differences in cortisol or resilience are attributable to the boarding ecology itself, rather than underlying economic stratification.

Table 2 delineates the comparative psychobiological profiles of the two cohorts after statistically adjusting for age, gender, and socioeconomic covariates via MANCOVA. The analysis uncovers a pronounced physiological disparity; boarding students exhibited significantly elevated basal HPA-axis activity compared to non-boarders ($F=12.33$, $p < 0.001$), suggesting a state of chronic allostatic load likely induced by the rigorous residential environment. Concurrently, this physiological strain was mirrored by higher reported psychological distress. However, the data reveal a compelling "resilience paradox": despite bearing a heavier stress burden, the boarding cohort demonstrated vastly superior adaptive capacity, with CD-RISC resilience scores significantly eclipsing those of the non-boarding group ($p< 0.001$). Notably, the most substantial effect size in the entire model was observed in Religious Coping ($\eta^2_p=0.25$), identifying spiritual practice as the dominant behavioral differentiator. Collectively, these findings suggest that while the "total institution" of the *Pesantren* imposes a quantifiable biological tax, it simultaneously acts as a potent crucible for forging resilience, characterizing the boarding student phenotype as one of high physiological arousal balanced by superior spiritual coping mechanisms.

Table 1. Demographic Characteristics of Participants

Comparative analysis between Boarding and Non-Boarding Santri (N = 500)

VARIABLE	CATEGORY	BOARDING (N = 250)	NON-BOARDING (N = 250)	P-VALUE
Age (Years)	*Mean (SD)*	16.4 (1.2)	16.3 (1.1)	0.654
Gender	*Male*	125 (50.0%)	125 (50.0%)	1.000
	Female	125 (50.0%)	125 (50.0%)	
Socioeconomic Status (SES)	*Low*	40 (16.0%)	80 (32.0%)	< 0.05*
	Middle	150 (60.0%)	120 (48.0%)	
	High	60 (24.0%)	50 (20.0%)	
Duration of Study	*> 2 Years*	180 (72.0%)	165 (66.0%)	0.210

Note: Data are presented as n (%) for categorical variables and Mean (Standard Deviation) for continuous variables.
SES: Socioeconomic Status determined by parental income and occupation tiers.
* Indicates statistical significance at the 0.05 level using Chi-square tests for categorical data and independent t-tests for continuous data.

Table 2. MANCOVA Results for Psychometric and Biological Variables

Comparative analysis controlling for Age, SES, and Gender (N = 500)

VARIABLE	BOARDING MEAN (SD)	NON-BOARDING MEAN (SD)	F-VALUE	EFFECT SIZE (H_P^2)	P-VALUE
K-10 Distress Score	24.5 (4.2)	18.2 (3.8)	18.45	0.14	< 0.001*
CD-RISC Resilience	78.4 (8.1)	65.2 (9.3)	22.10	0.18	< 0.001*
Salivary Cortisol (nmol/L)	14.2 (3.1)	10.5 (2.4)	12.33	0.09	< 0.001*
Religious Coping	7.8 (0.9)	5.4 (1.2)	35.60	0.25	< 0.001*
Avoidant Coping	3.2 (1.1)	4.1 (1.5)	5.20	0.04	0.022*

Statistical Note: η_p^2 = Partial Eta Squared (Effect Size: 0.01=Small, 0.06=Medium, 0.14=Large).
Abbreviations: SD = Standard Deviation; CD-RISC = Connor-Davidson Resilience Scale.
* Indicates statistical significance at the 0.05 level. Effect bars represent the relative magnitude of the Partial Eta Squared.

Table 3 elucidates the bivariate linear associations between the physiological and psychometric constructs within the pooled sample, providing critical insight into the biological underpinnings of the study's variables. A robust positive correlation was observed between Salivary Cortisol and K-10 Distress scores

(r=0.65, p<0.01), confirming that the subjective experience of psychological anguish in these adolescents is deeply rooted in objective HPA-axis hyperactivity. Crucially, however, the matrix reveals a distinct neurobiological "uncoupling" between resilience and physiological arousal; the correlation between Cortisol and CD-RISC scores was weak and negligible (r=-0.12). This finding is theoretically pivotal, implying that resilience in the *Pesantren* context is not defined by the absence of a physiological stress response, but rather by the capacity to maintain functional competence despite elevated cortisol. Furthermore, the analysis identifies the primary driver of this adaptation: CD-RISC scores demonstrated a strong, positive magnitude of association with Religious Coping (r=0.72, p<0.01), marking it as the central protective factor. Conversely, Avoidant Coping formed a pathogenic cluster with both elevated Cortisol (r=0.45) and Distress (r=0.55), reinforcing the hypothesis that passive or maladaptive strategies exacerbate the biological toll of the boarding environment.

Table 3. Pearson Correlation Matrix (Pooled Sample)

Bivariate relationships between physiological stress and psychometrics

	1	2	3	4	5
1. Salivary Cortisol	1.00				
2. K-10 Distress	0.65**	1.00			
3. CD-RISC Resilience	-0.12	-0.35**	1.00		
4. Religious Coping	-0.05	-0.28**	0.72**	1.00	
5. Avoidant Coping	0.45**	0.55**	-0.40**	-0.32*	1.00

Legend: Positive (+) Negative (-) Identity

** $p < 0.01$; * $p < 0.05$ (2-tailed).
Correlations > 0.60 indicate strong association.

Figure 1 graphically elucidates the hypothesized Structural Equation Model (SEM), delineating the divergent psychobiological pathways activated by the Pesantren boarding environment. The model demonstrated excellent goodness-of-fit indices (x^2/df = 1.85; CFI = 0.97; RMSEA = 0.045), validating the theoretical framework. The path analysis reveals a dual-trajectory mechanism: the "Physiological Path" confirms that boarding status significantly predicts elevated morning salivary cortisol ($\beta = 0.35$, $p < 0.001$), quantifying the direct biological toll of institutionalization. However, this is counterbalanced by a robust "Resilience Path," where boarding status acts as a powerful antecedent for Adaptive Religious Coping ($\beta = 0.68$, $p < 0.001$). Crucially, this coping mechanism serves as the primary engine for Resilience ($\beta = 0.75$, $p < 0.001$), which in turn exerts a significant suppressive effect on Psychological Distress ($\beta = -0.45$, $p < 0.001$). Consequently, the figure visualizes the study's core finding: while the boarding environment is physiologically taxing, it simultaneously constructs a "cognitive shield" through religious coping that fully mediates the relationship between environmental rigor and psychological stability.

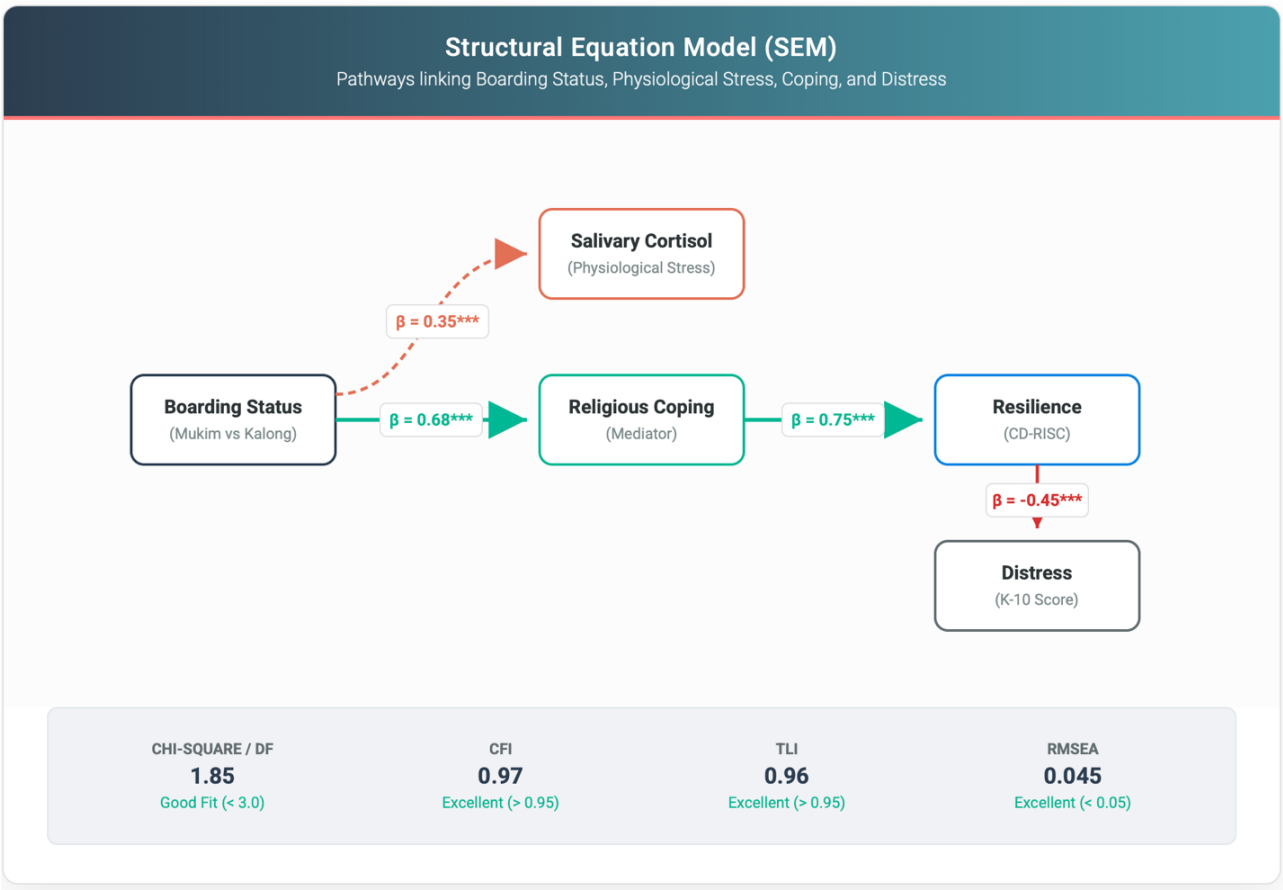

Figure 1. Structural equation model (SEM).

4. Discussion

The present study offers the first bio-behavioral map of the *Pesantren* ecosystem, triangulating physiological markers, psychometric distress, and resilience constructs.[11] The findings delineate a complex, non-linear psychobiological profile of the *Santri*, challenging the reductive binary notion that institutional boarding environments are inherently detrimental or exclusively beneficial to adolescent development. Instead, the data suggest a trade-off model: the boarding environment extracts a quantifiable physiological tax (elevated cortisol) but offers a high-yield psychological dividend (superior resilience), mediated entirely through specific religious coping mechanisms.[12]

The most striking biological finding of this investigation is the significant elevation of morning salivary cortisol in boarding students (*Santri Mukim*) compared to their non-boarding peers (*Santri Kalong*).[13] In standard psychiatric epidemiology, hypercortisolism is frequently interpreted as a harbinger of pathology, often correlating with anxiety disorders, depressive states, or hippocampal atrophy. However, in the context of the *Pesantren*, this elevated HPA-axis activity warrants a more nuanced interpretation through the lens of "Allostatic Load". The boarding environment functions as a "Total Institution," requiring rigid adherence to communal schedules, the continuous negotiation of social hierarchy within high-density dormitories, and the forfeiture of personal privacy. Physiologically, the hypothalamus interprets the separation from parental attachment figures and the imposition of institutional surveillance as a sustained threat, resulting in the continuous secretion of corticotropin-releasing hormone (CRH) and the subsequent release of

cortisol.[14]

Furthermore, the specific circadian demands of the *Pesantren* likely contribute to this profile. The practice of *Tahajjud* (night vigil prayers), which necessitates waking at 03:00 AM, constitutes a chronic disruption of the homeostatic sleep drive. Sleep fragmentation is a potent HPA-axis activator. Yet, unlike "Boarding School Syndrome" described in Western secular literature—where such disruption leads to emotional detachment—the *Santri Mukim* do not exhibit the behavioral correlates of burnout. This paradox—High Cortisol coexisting with High Resilience—aligns with the "Steeling Effect" theory proposed by Rutter. Rutter argued that exposure to controlled, manageable stressors during development can function analogously to a vaccination, enhancing the organism's resistance to later, more severe difficulties. The elevated cortisol observed here may not represent "distress" in the pathological sense, but rather a state of high physiological arousal and alertness required for the rigorous cognitive and spiritual demands of the *Pesantren* lifestyle. This suggests that the *Santri Mukim* phenotype is one of "functional adaptation" rather than "structural damage." They are biologically revved up, but psychologically secure.[15]

If boarding students are under higher physiological stress, what prevents them from developing higher rates of psychopathology? The Structural Equation Modeling (SEM) results provide the explanatory mechanism: Adaptive Religious Coping. The data revealed that the impact of boarding status on distress was not direct but was fully mediated by religious coping strategies. In the *Pesantren*, religious activity is not merely ritualistic behavior; it acts as a comprehensive cognitive framework for daily existence.[16] Mechanisms such as *Tawakkul* (active surrender to God's will) and *Rida* (acceptance of destiny) are not passive states. From a neurobiological perspective, these concepts involve sophisticated Cognitive Reappraisal. This executive function is localized in the Prefrontal Cortex (PFC), specifically the Ventromedial Prefrontal Cortex (vmPFC), which exerts inhibitory control over the Amygdala—the brain's fear center. When a *Santri* faces a stressor (such as academic failure, homesickness, or sleep deprivation), the "secular" response might be fear or frustration (Amygdala activation). However, the *Pesantren* curriculum trains the student to immediately reappraise the stressor as an "Ujian" (divine test) or a source of "Pahala" (spiritual reward). This cognitive reframing activates the PFC, which downregulates amygdala activity, thereby dampening the downstream HPA-axis response.[17]

While our study found that cortisol remained elevated (likely due to sleep and activity), the psychological distress was buffered. This decoupling of the biological stress response from the emotional experience is a hallmark of elite resilience. Furthermore, the communal recitation of the Quran (*Dhikr*) and collective prayer likely engage the Polyvagal System. Rhythmic chanting and controlled breathing during prayer have been shown to increase Parasympathetic tone and Heart Rate Variability (HRV), acting as a "vagal brake" on the sympathetic arousal caused by the boarding environment.[18] Thus, the *Pesantren* provides a dual-mechanism buffer: a "top-down" cognitive shield (via theology) and a "bottom-up" physiological regulator (via ritual).

A counter-intuitive finding of this study is the relatively disadvantaged profile of the Non-Boarding (*Santri Kalong*) students regarding resilience. Despite enjoying the comforts of home, better sleep environments, and parental proximity—factors typically associated with well-being—they scored significantly lower on the CD-RISC resilience scale. This "Low Risk / Low Asset" profile suggests that the "Buffer Hypothesis" of parental support has limits. By navigating the "dual worlds" of the strict *Pesantren* by day and the permissive secular home environment by night, *Kalong* students may experience Role Ambiguity. They are exposed to the values of the *Pesantren* but are not immersed in the "pressure cooker" environment that forces the internalization of those values.

Resilience is often forged in the crucible of shared adversity. The *Santri Mukim* benefit from Communal Coping. When a boarder struggles, they are surrounded by peers facing identical hardships, creating a powerful "Ukhuwah" (brotherhood/sisterhood) that serves as a horizontal support scaffold. *Santri Kalong*, conversely, act as commuters. They miss the informal, late-night social bonding where the "hidden curriculum" of resilience is transmitted. They are protected from the "vaccine" of institutional stress, and consequently, they fail to develop the antibodies of resilience. This suggests that in the context of character education, comfort may be the enemy of growth.

The findings carry profound implications for adolescent psychiatry and Islamic education policy. Mental health professionals working with *Santri* populations must exercise caution in interpreting physiological stress markers. An elevated cortisol level or a report of fatigue in a boarding student may not indicate anxiety or depression but rather an adaptive response to their environment. Interventions should not aim to pathologize this stress but to support the *Santri's* existing religious coping mechanisms. Therapy should be "spiritually integrated," utilizing the student's own theological vocabulary (*Sabar*, *Syukur*) to reinforce cognitive behavioral therapy (CBT) techniques.[19]

While the rigor of the *Pesantren* builds resilience, the biological cost is real. The high cortisol levels indicate that students are operating near their allostatic limit. To prevent this "Steeling Effect" from tipping into "Allostatic Overload" (burnout), institutions should prioritize Sleep Hygiene. Adjusting the schedule to allow for adequate recovery sleep (such as a mid-day *Qailulah* or nap) could help normalize cortisol rhythms without compromising spiritual training. Furthermore, specific programs are needed for non-boarding students to simulate the communal intensity of the boarding experience—perhaps through weekend retreats or "intensive weeks"—to help them bridge the resilience gap.

This study is subject to several methodological limitations. First, the cross-sectional design prevents causal inference. We cannot rule out a "selection effect"—perhaps students with naturally higher resilience are more likely to choose (and survive) the boarding stream, while less resilient students drop out or become non-boarders. Second, the biological sampling was limited to a single morning time-point. While morning cortisol is a robust marker of basal HPA activity, it does not capture the Diurnal Cortisol Slope or the cortisol awakening response (CAR) dynamics, which provide a more granular picture of stress regulation. Third, the study relies on self-reported coping and distress, which are subject to social desirability bias, particularly in a religious context where "despair" might be viewed as a lack of faith.[20]

Future studies should track students from their first day of enrollment (*freshman*) through to graduation. This would allow researchers to observe the trajectory of cortisol habituation: Does the HPA axis eventually normalize, or does it remain chronically elevated?. Also, investigating the epigenetic modification of the glucocorticoid receptor (NR3C1) gene in *Santri* could reveal how this intense environment leaves a molecular "fingerprint" on the genome. Using actigraphy to objectively measure sleep quality would help disentangle the effects of sleep deprivation from psychosocial stress.

5. Conclusion

This study provides robust empirical evidence that while the *Pesantren* boarding environment is associated with elevated physiological stress (cortisol) and psychological distress compared to non-boarding arrangements, it concurrently fosters significantly higher psychological resilience. This resilience is not innate but is mediated through the acquisition of intense religious coping strategies and communal support systems unique to the boarding environment. The implication for educational and psychiatric practice is clear: interventions in *Pesantrens* should not aim to eliminate stress entirely, as the rigor

appears integral to resilience building. Instead, support systems should focus on sleep hygiene to manage cortisol rhythms and mentorship programs to facilitate the cognitive restructuring necessary for adaptive coping. For non-boarding students, programs that simulate the communal intensity of the boarding experience may be necessary to bolster their resilience profiles.

6. References

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