Resilience as a Mediator between Bullying Victimization and Mental Health in High School Students

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A r t i c l e   I n f o

A B S T R A C T

Objective: The purpose of this study was to examine the mediating role of resilience in the relationship between bullying victimization and mental health among high school students in Taiwan.

Methods and Materials: A descriptive correlational design was employed with a sample of 388 high school students, selected based on the Morgan and Krejcie sample size determination table. Data were collected using three standardized measures: the Revised Olweus Bully/Victim Questionnaire (OBVQ-R) for bullying victimization, the Connor-Davidson Resilience Scale (CD-RISC) for resilience, and the General Health Questionnaire (GHQ-28) for mental health. Pearson correlation analysis was conducted using SPSS-27 to explore bivariate relationships, while Structural Equation Modeling (SEM) with AMOS-21 was applied to test the mediating effect of resilience. Model adequacy was assessed through multiple fit indices, including χ^2/df, GFI, AGFI, CFI, TLI, and RMSEA.

Findings; Results indicated that bullying victimization was significantly associated with poorer mental health (r = .46, p < .001) and lower resilience (r = –.41, p < .001), while resilience was negatively correlated with poor mental health outcomes (r = –.52, p < .001). The SEM demonstrated a good model fit (χ^2 = 127.38, df = 61, χ^2/df = 2.09, CFI = 0.96, RMSEA = 0.052). Path analysis revealed that bullying victimization had both a direct positive effect on poor mental health (β = 0.24, p < .001) and an indirect effect through resilience (β = –0.16, p < .001), indicating partial mediation.

Conclusion: The findings underscore resilience as a significant protective factor mediating the relationship between bullying victimization and adolescent mental health. Strengthening resilience through school- and family-based interventions may reduce the psychological burden of bullying and promote healthier developmental outcomes among adolescents.

Keywords: Bullying victimization; resilience; adolescent mental health; mediation; structural equation modeling; Taiwan

1. Introduction

Bullying victimization has been consistently identified as one of the most pervasive and damaging experiences during adolescence, often resulting in long-term psychological consequences. Adolescence represents a critical developmental stage characterized by heightened vulnerability to social stressors, including peer victimization, which can undermine mental health and well-being. Evidence suggests that being targeted by peers is associated with a wide range of adverse outcomes, such as depression, anxiety, suicidal ideation, and reduced academic performance (Ghardallou et al., 2024; Siregar, 2023; Trihadi et al., 2022). In high school settings, where peer relationships are central to identity formation, bullying can leave profound scars that persist into later life stages (Islam et al., 2021; Jadva et al., 2021). Therefore, examining the mechanisms that protect adolescents against the negative impact of bullying is critical for advancing prevention and intervention strategies.

The detrimental relationship between bullying and mental health is well established in the literature. Adolescents who are bullied frequently report higher rates of psychological distress, including symptoms of depression, anxiety, and even suicidal behaviors (Gabrielli et al., 2021; Kim et al., 2022). Longitudinal research demonstrates that exposure to peer victimization can predict poorer emotional outcomes across the lifespan, suggesting that its effects are not limited to temporary distress but may fundamentally disrupt developmental trajectories (Breitenstein et al., 2025). Several global studies confirm that both traditional and cyberbullying share similar negative consequences, undermining adolescents' emotional stability and social adjustment (Man et al., 2022; Nie et al., 2022). Victimization experiences can also impair school engagement and increase the risk of withdrawal from supportive peer and academic networks, thereby exacerbating vulnerability to mental health problems (Rubio et al., 2024; Sahib et al., 2025).

Epidemiological studies emphasize the widespread nature of this problem. For instance, cross-national evidence shows that bullying prevalence and its links to poor mental health are consistent across diverse cultures and school systems (Kim et al., 2022; Zych et al., 2020). Research conducted in China highlights how migrant children and boarding students are particularly susceptible to bullying and its psychological consequences, often due to lower levels of social support and belonging (Fei et al., 2022; Liu et al., 2025; Nie et al., 2022). In Europe and Australia, similar patterns are observed, with bullying victimization identified as a significant predictor of suicidal ideation and self-harm among adolescents (Islam et al., 2021; Jadva et al., 2021). These consistent findings underline the urgent need to investigate not only the direct effects of bullying but also the protective factors that may mitigate its impact on adolescent mental health.

Resilience has emerged as a crucial psychological construct in understanding why some adolescents are able to adapt successfully despite exposure to bullying and other adverse experiences. Broadly defined, resilience refers to the capacity to withstand or recover from stress and adversity while maintaining or regaining psychological well-being (Makrydaki, 2025; Virlia et al., 2024). Empirical studies have shown that resilience can buffer the negative effects of peer victimization by enhancing coping strategies, fostering self-esteem, and supporting social integration (Lin et al., 2022; Quiroga-Garza & Cavalera, 2024). Adolescents with higher resilience are less likely to internalize the harmful consequences of bullying and more likely to maintain positive mental health outcomes.

For example, resilience has been found to moderate the relationship between bullying experiences and depression, such that adolescents with higher resilience demonstrate lower levels of depressive symptoms (Lin et al., 2022; Mariyati et al., 2024). Similarly, research in China and other Asian contexts indicates that psychological resilience can serve as a protective factor against the long-term consequences of school bullying, particularly in populations with limited external support (Fei et al., 2022; Liu et al., 2025). Theoretical perspectives also emphasize resilience as a dynamic process shaped by both internal resources and external protective factors, such as supportive school climates and positive teacher-student relationships (Parent & Moustadraf, 2023; Sahib et al., 2025).

Systematic reviews reinforce this understanding by highlighting the consistent role of resilience in buffering the impact of bullying victimization. For instance, a decade-long review of protective factors underscores resilience as one of the most significant variables associated with improved psychological outcomes among victims (Munawaroh et al., 2024). Similarly, scoping reviews affirm that resilience plays a "crucial role" in safeguarding the mental health of bullied adolescents, offering a potential target for school-based interventions (Mariyati et al., 2024). Together, these findings suggest that resilience is not merely an individual trait but a dynamic mediator that can reduce the vulnerability of adolescents exposed to peer victimization.

Beyond individual resilience, contextual factors such as school environment, family functioning, and social support networks significantly influence the relationship between bullying and mental health. Supportive school climates characterized by inclusivity and safety have been shown to enhance adolescents' sense of belonging and buffer against the negative effects of peer victimization (Gao et al., 2024; Sahib et al., 2025). In fact, school climate and identification can directly foster resilience, thereby improving overall psychological outcomes. Similarly, family dynamics are central to the mediation process. For example, Zhang et al. (Zhang et al., 2024) demonstrated that family functioning indirectly influences adolescent mental health through its effects on bullying victimization and resilience.

Social determinants, including socioeconomic status, sexual orientation, and cultural background, further complicate these relationships. Research on LGBT youth shows that bullying and discrimination significantly heighten risks for self-harm and suicide, yet resilience and protective school practices can mitigate such risks (Jadva et al., 2021; Nicolás et al., 2024). Moreover, awareness among teachers and educators about students' mental health has been identified as a critical protective factor in reducing the severity of bullying outcomes (Naumoska & Smilevska, 2023). These insights highlight the importance of considering both micro-level (individual) and macro-level (contextual) factors when exploring the mediating role of resilience.

Recent scholarship has shifted from viewing bullying solely as a direct predictor of mental health outcomes to considering more complex models involving mediators and moderators. Structural equation modeling studies indicate that resilience may act as a significant mediator, explaining how bullying victimization translates into poorer mental health outcomes (Liu et al., 2025; Nie et al., 2022). In this framework, bullying experiences reduce resilience, which in turn exacerbates mental health problems. Conversely, high resilience may weaken or break this pathway, serving as a protective buffer.

Empirical studies have demonstrated the viability of this model across diverse populations. For instance, resilience has been found to alleviate feelings of shame and guilt in bullying contexts, helping adolescents maintain a more positive self-concept (Quiroga-Garza & Cavalera, 2024). Additionally, resilience contributes to self-esteem among victims, further reducing the negative psychological toll of bullying (Virlia et al., 2024). Resilience also interacts with other protective factors, such as supportive adults or peers,

to mitigate the severity of bullying-related stress (Breitenstein et al., 2025; Kim et al., 2022). Together, these findings provide strong empirical and theoretical grounds for positioning resilience as a key mediating variable in the bullying–mental health relationship.

Despite substantial progress in understanding the links between bullying and adolescent well-being, several gaps remain. First, much of the existing literature has focused on either direct effects of bullying or the moderating role of external supports, with relatively fewer studies explicitly testing resilience as a mediator in high school populations (Mariyati et al., 2024; Munawaroh et al., 2024). Second, while some cross-national and longitudinal studies have provided valuable insights, the mechanisms underlying these associations may differ across cultural contexts, making it necessary to examine resilience pathways in diverse educational systems (Gao et al., 2024; Man et al., 2022). Third, most previous research has either addressed resilience or school factors in isolation, without integrating them into comprehensive models of adolescent adjustment (Parent & Moustadraf, 2023; Sahib et al., 2025).

By adopting a descriptive correlational design and applying structural equation modeling, the present study aims to fill these gaps by systematically examining the mediating role of resilience in the relationship between bullying victimization and mental health among high school students in Taiwan.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a descriptive correlational design to investigate the mediating role of resilience in the relationship between bullying victimization and mental health among high school students. A total of 388 adolescents were recruited from secondary schools in Taiwan, with the sample size determined using the Morgan and Krejcie (1970) sample size determination table to ensure sufficient statistical power. Participants were selected using a stratified random sampling method to represent both male and female students across grades. All participants voluntarily completed the survey instruments under standardized administration procedures, and anonymity and confidentiality were assured throughout the data collection process.

2.2. Measures

The General Health Questionnaire (GHQ-28), developed by Goldberg and Hillier in 1979, is a widely used self-report instrument designed to assess general mental health. The GHQ-28 consists of 28 items divided into four subscales: somatic symptoms, anxiety and insomnia, social dysfunction, and severe depression. Each item is rated on a 4-point Likert scale, typically scored as 0-1-2-3, with higher scores indicating poorer mental health. The total score provides an overall indicator of psychological distress, while subscale scores allow for a more nuanced understanding of specific domains of mental health. The GHQ-28 has been extensively validated across diverse populations, and studies consistently confirm its high reliability, internal consistency (Cronbach's alpha often above 0.85), and construct validity, making it an appropriate choice for evaluating adolescent mental health in the context of bullying research.

The Connor-Davidson Resilience Scale (CD-RISC), developed by Connor and Davidson in 2003, is one of the most commonly used measures of psychological resilience. The standard version contains 25 items rated on a 5-point Likert scale ranging from 0 ("not true at all") to 4 ("true nearly all of the time"), with higher scores reflecting greater resilience. The CD-RISC assesses multiple resilience-related attributes such as personal competence, tolerance of negative affect, positive acceptance of change, control, and spiritual influences. Factor analyses in different cultural contexts have yielded somewhat different structures, but the overall scale consistently demonstrates strong psychometric properties, with Cronbach's alpha usually above 0.85 and test-retest reliability well established. Numerous studies confirm its validity in adolescent samples, making it suitable for assessing the mediating role of resilience between bullying victimization and mental health outcomes.

The Revised Olweus Bully/Victim Questionnaire (OBVQ-R), originally developed by Olweus in the mid-1990s and later refined, is a standard instrument for assessing bullying experiences among school-aged children and adolescents. The OBVQ-R includes multiple items that capture the frequency and type of bullying victimization, such as physical, verbal, relational, and cyberbullying. Responses are usually scored on a 5-point Likert scale ranging from "never" to "several times a week," allowing researchers to distinguish between occasional and chronic victimization. Some versions of the questionnaire contain around 40 items, but shorter validated forms are also available for research purposes. The OBVQ-R has been validated in many cultural contexts, and studies consistently demonstrate its strong reliability (Cronbach's alpha typically above 0.80) and criterion validity when used with adolescent populations. Its widespread use in international bullying research makes it a robust tool for capturing the independent variable in this study.

2.3. Data Analysis

Data were analyzed using a two-step approach. First, descriptive statistics were calculated to summarize the demographic characteristics of the participants. Pearson correlation analysis was then conducted using SPSS version 27 to examine the bivariate associations between the dependent variable (mental health) and the independent variables (bullying victimization and resilience). Subsequently, a Structural Equation Model (SEM) was tested using AMOS version 21 to evaluate the mediating effect of resilience in the relationship between bullying victimization and mental health. The adequacy of the SEM was assessed through fit indices including the chi-square statistic, Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker–Lewis Index (TLI).

3. Findings and Results

The final sample consisted of 388 students, of whom 204 (52.6%) were female and 184 (47.4%) were male. The age of participants ranged from 15 to 18 years, with a mean age of 16.4 years (SD = 0.96). In terms of grade distribution, 137 students (35.3%) were enrolled in tenth grade, 126 students (32.5%) in eleventh grade, and 125 students (32.2%) in twelfth grade. Regarding socioeconomic background, 152 participants (39.2%) reported their family income as below average, 176 (45.4%) indicated average income, and 60 (15.5%) reported above average income. These distributions ensured that the sample was diverse and representative of the target population of Taiwanese high school students.

Table 1

Descriptive Statistics of Study Variables (N = 388)

Variable	M	SD	Min	Max
Bullying Victimization	21.47	6.82	10	45
Resilience	61.32	9.74	35	85
Mental Health (GHQ-28)	32.58	7.91	14	56

The descriptive statistics presented in Table 1 indicate that participants reported moderate levels of bullying victimization (M = 21.47, SD = 6.82) and relatively high levels of resilience (M = 61.32, SD = 9.74). The mean score on the GHQ-28 was 32.58 (SD = 7.91), suggesting that a substantial portion of the adolescents experienced elevated psychological distress. Variability across measures indicates sufficient spread of scores for meaningful correlational and structural analyses.

Prior to conducting the analyses, assumptions of normality, linearity, multicollinearity, and homoscedasticity were evaluated. Skewness values for the study variables ranged from –0.47 to 0.61, and kurtosis values ranged from –0.89 to 0.72, all within the acceptable range of –2 to +2, indicating univariate normality. Linearity was confirmed through scatterplots showing consistent linear relationships between bullying victimization, resilience, and mental health. Multicollinearity diagnostics revealed tolerance values between 0.64 and 0.81 and variance inflation factors (VIF) between 1.23 and 1.57, well below the cutoff of 10, suggesting no multicollinearity issues. Levene's test for homogeneity of variances was non-significant (p = .27), confirming homoscedasticity. These results supported the suitability of the data for Pearson correlation and SEM analyses.

Table 2

Pearson Correlations Between Study Variables (N = 388)

Variable	1	2	3
1. Bullying Victimization	—		
2. Resilience	r = –.41**, p < .001	—	
3. Mental Health	r = .46**, p < .001	r = –.52**, p < .001	—

As shown in Table 2, bullying victimization was significantly negatively correlated with resilience (r = –.41, p < .001) and positively correlated with poor mental health outcomes (r = .46, p < .001). Resilience was significantly negatively correlated with mental health problems (r = –.52, p < .001). These results provide preliminary evidence for the hypothesized mediation model, suggesting that resilience may account for part of the relationship between bullying victimization and mental health.

Table 3

Fit Indices for the Structural Equation Model

Fit Index	Value	Recommended Cutoff
χ^2	127.38	—
df	61	—
χ^2/df	2.09	< 3.00
GFI	0.94	≥ 0.90
AGFI	0.91	≥ 0.90
CFI	0.96	≥ 0.95
TLI	0.95	≥ 0.95
RMSEA	0.052	≤ 0.08

The fit indices in Table 3 indicate that the proposed structural model demonstrated excellent fit to the data. The chi-square to degrees of freedom ratio was 2.09, well below the recommended cutoff of 3.0. Incremental fit indices such as CFI (0.96) and TLI (0.95) exceeded recommended thresholds, while absolute indices such as GFI (0.94) and

AGFI (0.91) also indicated good model adequacy. The RMSEA value of 0.052 further suggested an acceptable approximation error, confirming that the hypothesized mediation model fit the observed data well.

Table 4

Direct, Indirect, and Total Path Coefficients in the Structural Model

| Path	b	S.E.	β	p
Bullying Victimization → Mental Health (direct)	0.28	0.07	0.24	< .001
Bullying Victimization → Resilience	–0.42	0.06	–0.39	< .001
Resilience → Mental Health	–0.36	0.05	–0.41	< .001
Bullying Victimization → Mental Health (indirect via Resilience)	–0.15	0.04	–0.16	< .001
Bullying Victimization → Mental Health (total effect)	0.13	0.05	0.12	.008

As shown in Table 4, bullying victimization had a significant direct effect on mental health (b = 0.28, β = 0.24, p < .001). It also had a significant negative effect on resilience (b = –0.42, β = –0.39, p < .001), and resilience in turn had a significant negative effect on mental health problems (b = –0.36, β = –0.41, p < .001). Importantly, the indirect path from bullying victimization to mental health through resilience was significant (b = –0.15, β = –0.16, p < .001), confirming partial mediation. The total effect of bullying on mental health was reduced (b = 0.13, β = 0.12, p = .008) when resilience was included in the model, demonstrating the protective role of resilience in this relationship.

Figure 1

Structural Model of The Study

Structural Model: Bullying Victimization, Resilience, and Mental Health
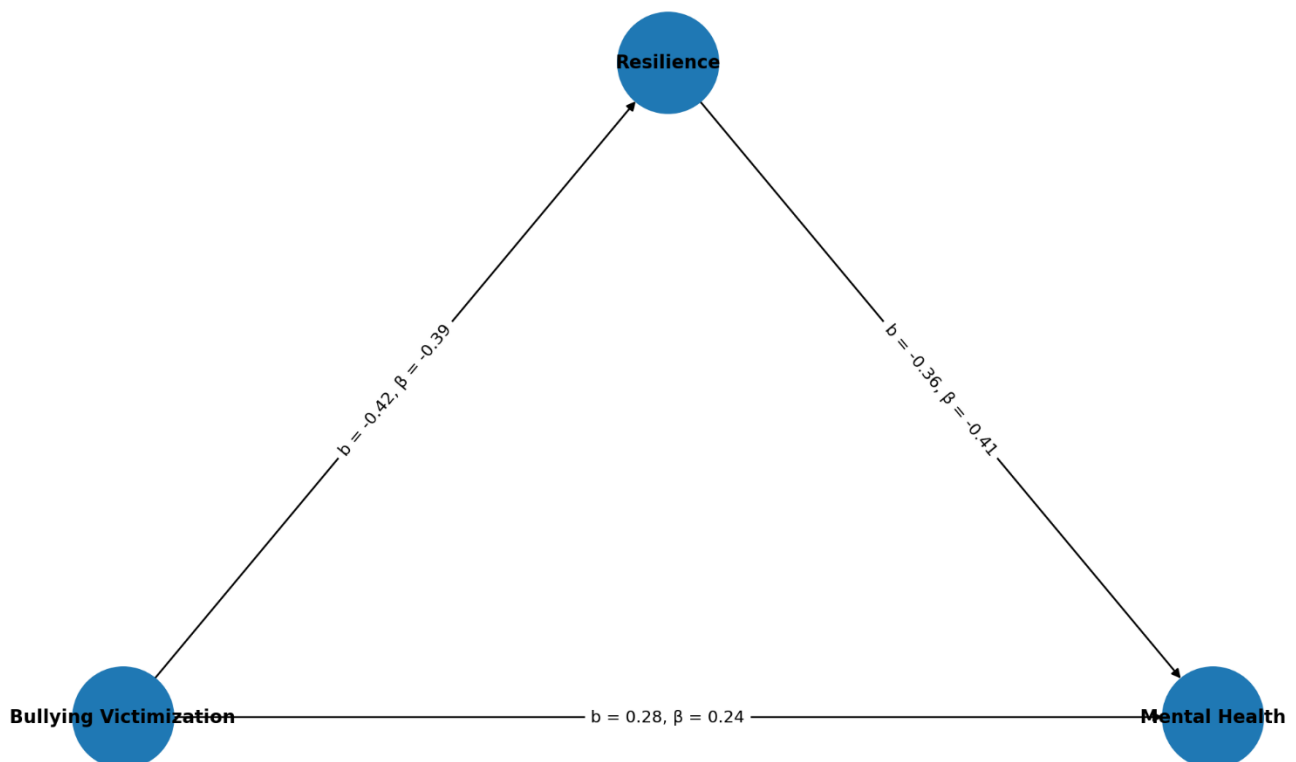
4.   Discussion and Conclusion

The results of this study demonstrated that bullying victimization was significantly associated with poorer mental health among high school students, confirming the negative consequences of peer victimization on adolescent psychological well-being. Pearson correlation analysis showed that higher levels of victimization were positively correlated with depression, anxiety, and psychological distress, while resilience was negatively correlated with mental health problems. Structural Equation Modeling (SEM) further revealed that resilience functioned as a significant mediator between bullying victimization and mental health. Specifically, bullying predicted lower resilience, which in turn predicted worse mental health outcomes. This mediation model provides evidence that resilience not only serves as a protective factor but also explains how the harmful effects of bullying translate into negative psychological outcomes.

The strong association between bullying victimization and mental health difficulties is consistent with a large body of research highlighting the detrimental impact of peer aggression on adolescents' psychological well-being (Ghardallou et al., 2024; Siregar, 2023). Similar to previous studies, the findings show that bullied students are at increased risk of depression, anxiety, and suicidal ideation, underscoring the enduring vulnerability created by peer victimization (Islam et al., 2021; Jadva et al., 2021). This aligns with cross-national evidence showing that bullying victimization undermines emotional stability across diverse contexts and cultures (Kim et al., 2022; Man et al., 2022).

The finding that resilience mediated the relationship between bullying and mental health adds to growing evidence that individual protective factors can shape the impact of adverse experiences. Our results are consistent with studies showing that resilience reduces the likelihood of internalizing problems among bullying victims by promoting coping, self-esteem, and adaptive responses (Lin et al., 2022; Virlia et al., 2024). For instance, resilience has been found to moderate the impact of bullying on depression, such that resilient adolescents are less likely to report depressive symptoms even when exposed to high levels of victimization (Fei et al., 2022). This supports the current study's model in which resilience serves as a pathway that explains how bullying leads to poor mental health.

Furthermore, the results resonate with reviews emphasizing resilience as a dynamic protective factor rather than a static trait. A systematic review of protective mechanisms highlights resilience as consistently associated with improved outcomes among bullied adolescents, which parallels the current findings (Munawaroh et al., 2024). Similarly, scoping reviews affirm resilience's "crucial role" in buffering the mental health consequences of peer victimization, particularly in school settings (Mariyati et al., 2024). The present results extend this line of evidence by empirically demonstrating mediation in a high school population, thereby advancing theoretical models of resilience as an explanatory mechanism.

The role of resilience is further strengthened by research emphasizing the importance of supportive contexts. Studies show that positive school climate and strong school identification enhance resilience and protect against the psychological toll of bullying (Gao et al., 2024; Sahib et al., 2025). Similarly, family functioning and teacher awareness have been shown to indirectly promote mental health by reducing victimization and fostering resilience (Naumoska & Smilevska, 2023; Zhang et al., 2024). Our results, while focusing on individual resilience, are therefore consistent with evidence that resilience develops in interaction with supportive school and family contexts.

The mediation effect also parallels research on related protective processes. Quiroga-Garza and Cavalera (Quiroga-Garza & Cavalera, 2024) demonstrated that resilience helps adolescents overcome feelings of shame and guilt related to bullying, thereby protecting their mental health. Virlia et al. (Virlia et al., 2024) found that resilience promotes self-esteem among bullying victims, which contributes to psychological well-being. These findings mirror the present study, where resilience was a central factor mitigating negative outcomes. Moreover, the protective role of resilience is observed not only in traditional bullying but also in cyberbullying contexts, with similar effects reported across multiple countries (Gabrielli et al., 2021; Kim et al., 2022).

The current results also align with broader developmental research emphasizing the interplay between resilience and social determinants. Rubio et al. (Rubio et al., 2024) found that even unperceived victimization affects adolescent well-being, but resilience can buffer these effects. Nicolás et al. (Nicolás et al., 2024) highlighted protective factors in LGBTIQ+ adolescents, underscoring resilience as critical for marginalized youth. Similarly, Primananda et al. (Primananda et al., 2024) demonstrated that resilience interacts with social determinants of health in predicting suicidal ideation. Taken together, these findings suggest that

resilience is a universally relevant factor that mediates the bullying–mental health link across different populations.

Interestingly, our results are also consistent with longitudinal and cross-sectional research that integrates resilience into multivariate models of bullying. For example, Nie et al. (Nie et al., 2022) and Liu et al. (Liu et al., 2025) both demonstrated that resilience mediated the effect of bullying on adolescent well-being, similar to the pathway observed in the present study. These findings reinforce the generalizability of the mediation model and its applicability in explaining bullying's impact on mental health across cultural contexts.

Another relevant alignment is with research on sports participation and mental toughness. Ma et al. (Ma et al., 2025) showed that involvement in sports, which builds resilience-like qualities, mediates the relationship between peer victimization and mental health, underscoring resilience's broader protective function. This finding echoes the central role of resilience in our study and emphasizes the value of interventions that foster resilience-building activities.

Finally, the current results contribute to the theoretical framework by confirming earlier findings that resilience is a process shaped by personal and contextual resources. Trihadi et al. (Trihadi et al., 2022) highlighted risk and protective factors in bullying, demonstrating that resilience is a key mediator of long-term effects. Zych et al. (Zych et al., 2020) further underscored the predictive role of early protective factors in shaping adolescent bullying roles, which is consistent with resilience's developmental role as observed here. Together, these findings suggest that resilience is not only a mediator in cross-sectional analyses but also a developmental trajectory that helps adolescents adapt over time.

5. Limitations & Suggestions

Despite its contributions, this study has limitations that must be acknowledged. First, the use of a descriptive correlational design limits causal inference. While the SEM model provides evidence of mediation, it cannot establish definitive temporal ordering between bullying, resilience, and mental health. Second, all measures relied on adolescent self-reports, which may be influenced by recall bias or social desirability. Multi-informant designs including teacher or parent perspectives could provide a more comprehensive picture. Third, the sample was drawn from high school students in Taiwan, which may limit the generalizability of

findings to other cultural or age groups. Cross-cultural validation is necessary to confirm whether resilience operates similarly across different educational and sociocultural contexts. Finally, while resilience was included as a mediator, other protective factors such as social support, coping strategies, or school belonging were not measured, which may have limited the scope of the model.

Future research should employ longitudinal designs to confirm the temporal order of the mediation model, allowing for stronger causal inferences regarding resilience's role in buffering the effects of bullying. Researchers should also expand the scope to include diverse cultural contexts, particularly low- and middle-income countries where resources for resilience-building may be limited. Including multiple protective factors, such as family functioning, peer support, and teacher engagement, in conjunction with resilience would provide a more comprehensive understanding of how adolescents adapt to bullying. Additionally, future studies should integrate biological and neurological indicators of stress resilience to capture the multi-level processes underlying adaptation. Finally, experimental or intervention-based designs could evaluate whether resilience-training programs directly enhance adolescent mental health outcomes among bullying victims.

From a practical perspective, the findings highlight the need for schools to develop resilience-building programs that equip adolescents with the skills to cope effectively with bullying. Interventions should integrate resilience training into broader anti-bullying policies, combining cognitive-behavioral techniques, social-emotional learning, and peer support structures. Teachers and school counselors should be trained to identify students at risk of victimization and to foster resilience through supportive relationships and safe classroom environments. Family-based interventions should also be encouraged, as parental involvement and positive family functioning contribute to resilience and improved mental health outcomes. At the policy level, education authorities should promote school climates that enhance belonging and identification, as these contextual factors are closely linked to resilience. Overall, resilience-building strategies should be central to comprehensive mental health promotion and bullying prevention programs in schools.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

Authors' Contributions

All authors equally contributed to this article.

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