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Profiling depression risk in international students: A latent difficulty model and moderation by personality and acculturation

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Abstract

International students are often dealing with academic, cultural, and social adjustments that can exacerbate their vulnerability for depression. In this study, secondary data analysis from a pre-COVID-19 large survey of 1,870 international university students in Taiwan were utilized. By using Latent Profile Analysis (LPA), three distinct groups were identified based on difficulty and depressive symptoms: *Well-Adjusted*; *Moderately Adjusted*; *At-Risk*. Depression levels, measured by the CES-D, differed significantly across profiles, with the At-Risk group exhibiting the highest symptom scores. Profiles also varied systematically in Big Five personality traits and acculturation strategies, with higher neuroticism and marginalization linked to elevated risk, while integration and traits such as extraversion and conscientiousness were associated with more adaptive outcomes. Moderation analyses revealed that openness, Chinese language ability, age, and marginalization shaped the strength of the profile–depression relationship, whereas gender and degree status showed minimal effects. Building on previous studies analyzing a combination of data published in 2014, 2016, and 2025, the current analyses showed the complexity of studying depression in the context of four areas: personal characteristics, acculturation strategies, situational contextual difficulties, and risk for depression. By applying a person-centered modeling approach, it highlights the importance of identifying vulnerable subgroups and tailoring institutional support to foster resilience and mental health among international students in Taiwan.

Keywords: international students, depression, latent profile analysis, acculturation strategies, Big Five personality traits, Taiwan, mental health, resilience

Profiling depression risk in international students: A latent difficulty model and moderation by personality and acculturation

1. Introduction

International student mobility has been increasing dramatically in newer decades, with estimates of greater than seven million students studying abroad in 2025 (Bohm et al., 2002). Even after the COVID-19 pandemic, study abroad or student mobility efforts are focused on regaining previous tractions in enrolment (Di Pietro, 2023), the possibility of redesigning course deliveries (Bradly et al., 2025), and the associated risks involved in studying abroad (Basterretxea Santiso & Sanz, 2022). Prior to COVID-19, Taiwan is proactively positioning itself as a host destination, in part, because of declining birth rates causing declining university enrolments (Chou et al., 2012). Wherein, there have been a marked increase of inbound students from Southeast Asia and Europe from government scholarships and a growing global interest in Mandarin studies. While this growth has increased Taiwan's image of internationalization, it has also identified gaps in understanding the lived experience and psychological adjustment of international students.

Over the past decade, substantial research has investigated the mental health and adjustment challenges faced by international students in Taiwan, drawing predominantly on data collected before the COVID-19 pandemic. While many of these prior and some recent analyses, which includes discussions of social adaptability (Lewis et al., 2013; Huang et al., 2014), acculturative stress (Ching, Chao et al., 2014), language barriers (Hu et al., 2022), and psychological related issues (Chang & Ching, 2025; Ching, et al., 2016; Ching, Lien et al., 2014; Wang & Ching, 2015), which have provided valuable baseline insight, which many predate the global disruptions that commenced with the onset of COVID-19. Importantly, several recent studies have documented a marked worsening of depression and anxiety among international students in the post-COVID era, as a result of pandemic-related lockdowns, remote learning, and diminished social support networks (Akiba et al., 2024; Shiratori et al., 2024).

As such, many studies have documented a range of mental health concerns among international students, including loneliness, stress, depression, and anxiety (Lucas, 2009; Muto et al., 2011). Empirical studies in Taiwan echo these findings (as noted above), showing that acculturative hassles such as academic struggles, language barriers, and negative social encounters are strongly linked with elevated stress and depressive symptoms (Ching, Chao et al., 2014; Roberts et al., 2010). Factor-analytic studies identified distinct categories of acculturative stressors, including adverse feelings, struggles, and communication difficulties, each of which contributes to students' mental health risks (Ching, Lien et al., 2014). More recent work also points to the role of situational changes in daily living, leisure, and academic adjustment that compound the pressures of study abroad (Ching, Lien et al., 2014; Lewis et al., 2013).

While most of the previous work in Taiwan has employed variable-centered approaches (e.g., regression, SEM), fewer studies have utilized person-centered models to investigate the heterogeneity of the student experience. Ethnographic descriptions highlight the multiple, multi-leveled narratives of individual adaptations (Ching et al., 2016), while survey-based studies show convergent validity for stress and acculturation measures (Ching, Lien et al., 2014; Chen & Ching, 2012). However, these methods consistently mask distinct groups of students who may vary in their vulnerability to depressive symptoms or in their reliance on specific acculturation strategies. In addition, person-centered methods (e.g., latent profile analysis [LPA]) provide an opportunity to discover subgroups and, effectively, generate more meaningful theoretical models that can assist in customizing support interventions (Chin & Ching, 2009).

The theoretical framework for this study is based on Berry's (1997, 2005) acculturation framework of assimilation, integration, separation, and marginalization which serves as a primary approach with which

international students navigate host cultures. Acculturative stress theory (Ward et al., 2001; Sam & Berry, 2010), indicates that acculturation strategies combined with contextual and personal resources serves as a predictor of adaptation outcomes related to well-being and mental health. Personality frameworks, such as the Big Five, have also been associated with the psychological adjustment and coping (Costa & McCrae, 1992); for example, extraversion and conscientiousness have been associated with resilience, whereas neuroticism has been associated with vulnerability to stress (Roberts et al., 2010). Evaluating acculturation strategies in context of personality dispositions may provide a broader framework from which to examine the risk of depression among international students.

Using a latent profile approach (LPA) (Collins & Lanza, 2010), the current study builds on the literature concerning international students in Taiwan by revealing specific subgroups of depression-risk and testing how personality traits and strategies of acculturation moderate their experience. This approach responds to the push for quality more nuanced models of international student adjustment. In addition to the methodological novelty of the present study, derived applied knowledge for universities hoping to design targeted support services for vulnerable subgroups is important. This is particularly salient in Taiwan, where international students comprise both a growing population and continue to be vital for institutional sustainability. Guided by these premises, the present study addresses the following research questions:

- What distinct latent profiles of international students can be identified based on reported difficulties and depression risk?
- How do these profiles differ in terms of personality traits (Big Five) and acculturation strategies (integration, assimilation, separation, marginalization)?
- To what extent do personality and acculturation variables moderate the relationship between profile membership and depression?
- How do demographic variables (e.g., age, gender, language ability, degree status) further influence depression outcomes across profiles?

2. Methodology

2.1 Study Design and Participants

This study employed a cross-sectional survey design (Creswell & Creswell, 2018), using secondary analysis of a large dataset originally collected to examine acculturation and well-being among international students in Taiwan. The original goal of the project was to examine acculturation models with international students in Taiwan. Participants completed the data collection and provided their informed consent. The original Institutional Review Board (IRB) approval was granted by Fu Jen Catholic University (Case Number C102015). The dataset consisted of 1,870 international university students enrolled in Taiwanese higher education institutions. Data were gathered through structured questionnaires distributed across multiple universities during 2013–2014. Participants included both degree-seeking students and short-term exchange students, with diverse national origins across Asia, Europe, and other regions. On average, students had stayed in Taiwan for approximately 18 months at the time of data collection. Informed consent was obtained from all participants, and survey completion was voluntary and anonymous.

2.2 Measures

Depression - Depression symptoms were assessed using the Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977), a 20-item self-report scale widely used in international student research. Scores of 16 or above were taken as indicative of possible clinical depression. The CES-D demonstrated good reliability in this dataset (Cronbach's (1951) Alpha = .84).

Acculturative Stress and Situational Difficulties - Situational changes and stressors were measured using the Short-term Study Abroad Situational Change Survey (SSCS; Ching, Lien et al., 2014). The instrument covers academic stress, leisure living, daily living, local viewpoints, and authoritative stress, reflecting common challenges faced by international students. Reliability coefficients ranged from .84 to .91 across subscales (see original paper for specific items used in the scale).

Acculturation Strategies - Berry's four acculturation strategies: integration, assimilation, separation, and marginalization; were assessed using scales adapted for international students in Taiwan (Ching, Chao et al., 2014). Each dimension was measured on Likert-type scales, with higher scores indicating stronger endorsement. Reliability coefficients ranged from .87 to .90 across subscales (see original paper for specific items used in the scale).

Personality Traits - The Big Five personality traits: extraversion, agreeableness, conscientiousness, neuroticism, and openness; were measured using a standardized inventory (Costa & McCrae, 1992), with subscale means computed for analysis. Reliability coefficients ranged from .70 to .90 across subscales.

Demographics - Demographic variables included gender, age, degree status (degree-seeking versus exchange), English language ability, and Chinese language ability. These were included as covariates and potential moderators of depression risk.

2.3 Data Analysis

All analyses were conducted in R. For LPA, students were classified into subgroups based on their reported difficulties and depression levels using the *mclust* R package (Scrucca et al., 2016). Model fit indices (Akaike Information Criterion; AIC, Bayesian Information Criterion; BIC, entropy) guided profile selection (Masyn, 2013). ANOVAs and Post-hoc Tests, wherein profiles were compared on CES-D, Big Five traits, and acculturation strategies. Tukey's HSD tests were applied for pairwise comparisons. For multinomial logistic regression, predictors of profile membership were examined, including acculturation strategies, personality traits, and demographics. Moderation analyses, *lavaan* R package (Rosseel, 2012) was used to test the interaction models whether personality traits (Big Five), acculturation strategies, and demographic variables moderated the relationship between profile membership and depression. Lastly, visualization of profiles and group differences were illustrated using boxplots, radar charts, and heatmaps to aid interpretation.

3. Results

3.1 What distinct latent profiles of international students can be identified based on reported difficulties and depression risk?

LPA yielded a three-profile solution with optimal fit indices. Profiles were labeled ***Well-Adjusted*** (n = 692), ***Moderately Adjusted*** (n = 957), and ***At-Risk*** (n = 221). Table 1 shows the CES-D scores differed significantly across profiles, $F(2, 1867) = 121.30$, $p < .001$, $\eta^2 = .12$. Tukey's post-hoc tests indicated that all three groups differed significantly from one another (all $p < .001$). While, Figure 1 illustrates the distribution of depression scores across the three profiles, highlighting the elevated CES-D scores in the At-Risk group.

Table 1
Descriptive Statistics and ANOVA Results for Depression by Profile

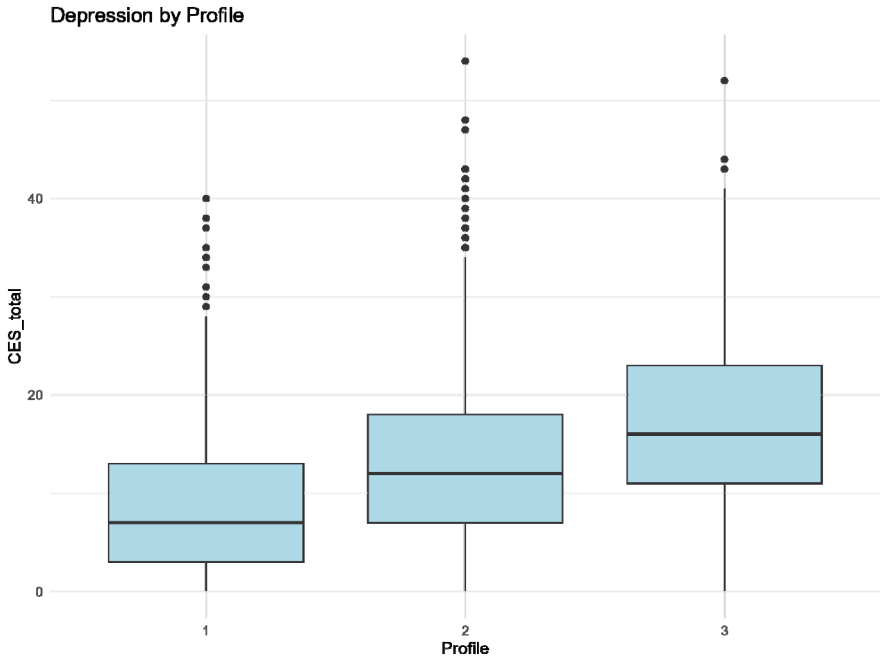
Profile	*n*	Mean (CES-D)	*SD*	Tukey Comparison
Well-Adjusted	692	8.6	7.27	1 < 2 < 3 (all $p < .001$)
Moderately Adjusted	957	13.5	8.42	
At-Risk	221	17.2	9.42	

Note. N = 1,870. SD = standard deviation.

As illustrated in Figure 1, depression scores varied substantially across the three latent profiles. The

Well-Adjusted group displayed the lowest and most tightly clustered CES-D scores, indicating generally low depression risk. In contrast, the *At-Risk* group exhibited both the highest mean scores and wider variability, suggesting that this subgroup not only faces elevated depressive symptoms but also contains students with particularly severe difficulties. The *Moderately Adjusted* group fell between these two extremes, reinforcing the graded differences identified in the ANOVA.

Figure 1. Distribution of Depression Scores Across the Three Profiles



Notes. Profile 1 = well-adjusted, Profile 2 = moderately adjusted, and Profile 3 = at risk students. *N* = 1,870.

3.2 How do these profiles differ in terms of personality traits and acculturation strategies?

Big Five Personality Traits – Table 2 shows the significant differences emerged across profiles for all five traits: extraversion, $F(2, 1867) = 29.61$, $p < .001$; agreeableness, $F(2, 1867) = 41.69$, $p < .001$; conscientiousness, $F(2, 1867) = 28.20$, $p < .001$; neuroticism, $F(2, 1867) = 64.37$, $p < .001$; and openness, $F(2, 1867) = 12.06$, $p < .001$. At-Risk students reported higher neuroticism and lower scores on extraversion, agreeableness, and conscientiousness.

Acculturation Strategies **-** Profiles also differed significantly on Berry's dimensions: integration, $F(2, 1867) = 26.57$, $p < .001$; assimilation, $F(2, 1867) = 58.32$, $p < .001$; separation, $F(2, 1867) = 16.64$, $p < .001$; and marginalization, $F(2, 1867) = 113.60$, $p < .001$. At-Risk students endorsed higher marginalization, while Well-Adjusted students endorsed higher integration.

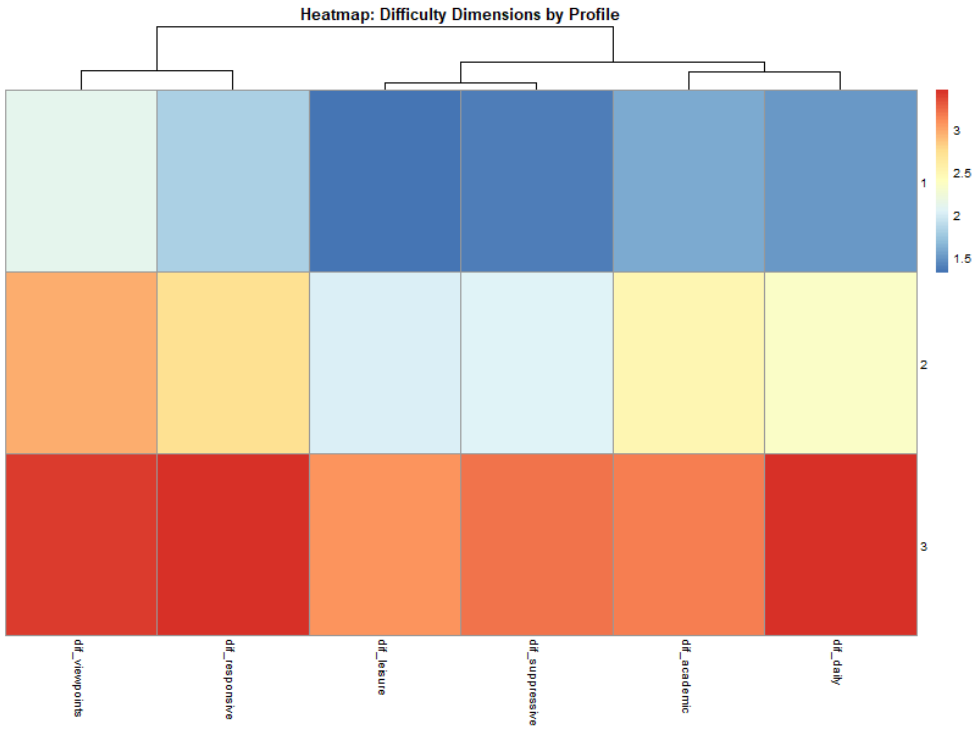
While Figure 2 (heatmap) presents the intensity of situational difficulties across the three profiles. Figure 3 (radar chart) illustrates the comparative patterns of *academic, daily, leisure, local viewpoint,* and *authoritative* stressors. Together, these figures show that *At-Risk* students reported consistently higher stress across all dimensions. Figure 2 provides a heatmap visualization of situational difficulties across profiles. A clear pattern emerged in which *Well-Adjusted* students consistently reported low scores across all domains (in light blue to blue), whereas *At-Risk* students reported high levels of difficulty (in red), particularly in cultural viewpoints and daily living. The *Moderately Adjusted* group showed intermediate levels of strain, with notable challenges in academic and leisure domains. This visual evidence supports the interpretation that profiles represent meaningful subgroups differentiated by the breadth and intensity of stressors.

Table 2

Profile Differences in Big Five Personality Traits and Acculturation Strategies

Variable	$F(2, 1867)$	p	Pattern of Results
Extraversion	29.61	< .001	At-Risk < Moderate < Well-Adjusted
Agreeableness	41.69	< .001	At-Risk < Moderate < Well-Adjusted
Conscientiousness	28.2	< .001	At-Risk < Moderate < Well-Adjusted
Neuroticism	64.37	< .001	At-Risk > Moderate > Well-Adjusted
Openness	12.06	< .001	At-Risk < Moderate ≈ Well-Adjusted
Integration	26.57	< .001	Well-Adjusted > Moderate > At-Risk
Assimilation	58.32	< .001	Moderate > Well-Adjusted > At-Risk
Separation	16.64	< .001	At-Risk > Moderate > Well-Adjusted
Marginalization	113.6	< .001	At-Risk > Moderate > Well-Adjusted

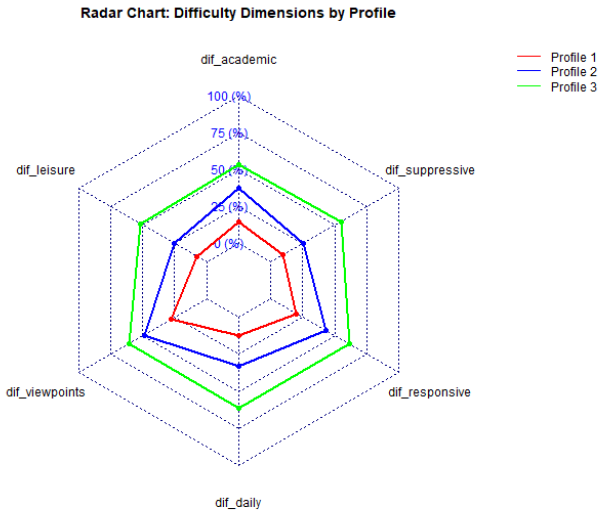
Figure 2. Intensity of Situational Difficulties Across the Three Profiles



Notes. Profile 1 = well-adjusted, Profile 2 = moderately adjusted, and Profile 3 = at risk students. N = 1,870. Acculturative difficulties or stressors = academic related, daily living issues, leisure or tourism related, local viewpoint or perspectives, and how to dealt with authoritative figures or individuals.

As shown in Figure 3, the radar chart highlights the distinctive shapes of difficulty profiles across five dimensions. The *Well-Adjusted* profile forms a compact, low-stress shape, whereas the *At-Risk* profile extends outward across all domains, indicating consistently elevated stress. The *Moderately Adjusted* profile demonstrates a mixed pattern, with moderate scores on most dimensions but a more pronounced elevation in academic stress. This comparative visualization underscores that while all students face some degree of adaptation challenge, the *At-Risk* group experiences more pervasive and generalized difficulties.

Figure 3. Illustrates the Comparative Patterns of Stressors



Notes. Profile 1 = well-adjusted, Profile 2 = moderately adjusted, and Profile 3 = at risk students. *N* = 1,870. Acculturative difficulties or stressors = academic related, daily living issues, leisure or tourism related, local viewpoint or perspectives, and how to dealt with authoritative figures or individuals.

3.3 To what extent do personality and acculturation variables moderate the relationship between profile membership and depression?

Moderation analyses revealed differential effects (see Table 3 for more details):

- **Openness × Profile:** Significant interaction, $F(2, 1864) = 6.07$, $p = .002$. Openness buffered depression risk more strongly for *At-Risk* students.
- **Neuroticism:** Strong main effect on depression, $\beta = 5.79$, $p < .001$, but interaction with profile membership was nonsignificant.
- **Extraversion, Agreeableness, Conscientiousness:** Each predicted lower depression, though no significant profile interactions were observed.
- **Marginalization:** Emerged as a strong predictor of profile membership in multinomial regression, aligning with higher depression risk.

Table 3
Summary of Significant Moderation Results

Moderator	Interaction Effect	*F* (df)	*p*	Interpretation
Openness	Significant	6.07 (2, 1864)	.002	Stronger buffering for At-Risk students
Neuroticism	NS	1.50 (2, 1864)	.223	Main effect only
Extraversion	NS	1.25 (2, 1864)	.287	Main effect only
Agreeableness	NS	1.94 (2, 1864)	.145	Main effect only
Conscientious.	NS	0.91 (2, 1864)	.402	Main effect only
Marginalization	Strong predictor of profile membership	-	< .001	Elevated risk in At-Risk group

Note. df = degrees of freedom, NS = non-significant.

3.4 How do demographic variables influence depression outcomes across profiles?

Gender showed a small nonsignificant effect on depression, $F(1, 1864) = 2.90$, $p = .089$, with no significant profile × gender interaction. Age had a positive main effect on depression, $\beta = 0.21$, $p < .001$, indicating older students reported higher depressive symptoms. Multinomial regression further revealed that degree-seeking students ($\beta = 0.57$, $p < .05$) and students with weaker Chinese proficiency ($\beta = –0.33$ to $–0.64$, $p < .05$) were more likely to belong to the *At-Risk* profile.

Table 4
Demographic Effects on Profile Membership and Depression

Variable	Effect	Statistic	*p*	Interpretation
Gender	NS	$F(1, 1864) = 2.90$	.089	No significant effect
Age	Positive effect	$\beta = 0.21$	< .001	Older students → higher depression
Degree status	Predicts risk	$\beta = 0.57$	.046	Degree-seeking → At-Risk group
Chinese ability	Protective effect	β = -0.33 to -0.64	< .05	Stronger Chinese → lower risk

Note. NS = non-significant.

4. Discussions

This study examined depression risk among international students in Taiwan using a person-centered approach. By employing LPA, the authors identified three distinct subgroups: Well-Adjusted, Moderately Adjusted, and At-Risk, that varied significantly in depression symptoms, personality traits, and acculturation strategies. These findings extend prior variable-centered studies of international students in Taiwan (e.g., Ching, Lien et al., 2014; Roberts et al., 2010) by uncovering heterogeneity in students' experiences and providing more nuanced insight into the interplay between acculturative stress and psychological well-being.

Profiles of Depression Risk - The identification of three distinct profiles confirms that not all international students experience study abroad in the same way. The At-Risk group's elevated depression scores align with earlier evidence that acculturative hassles, such as: academic struggles, daily living, and cultural viewpoints—are closely linked to negative psychological outcomes (Ching, Chao et al., 2014; Wang & Ching, 2015). The Well-Adjusted group's low depression levels reflect resilience and effective coping, echoing Lewis, et al.'s (2013) findings that supportive peer networks facilitate positive adaptation. The Moderately Adjusted group suggests that a large proportion of students face moderate stress yet avoid the severe symptomology of the At-Risk subgroup.

Personality and Acculturation Strategies - The results demonstrate systematic personality and acculturation differences across profiles. Students high in neuroticism were more likely to belong to the At-Risk profile, whereas extraversion, agreeableness, and conscientiousness characterized Well-Adjusted students. These findings support Costa and McCrae's (1992) model and prior research linking neuroticism to vulnerability (Roberts et al., 2010). Acculturation patterns also differentiated profiles: At-Risk students endorsed marginalization, while Well-Adjusted students endorsed integration. These results are consistent with Berry's (1997, 2005) acculturation framework and local evidence that integration supports positive adaptation, whereas marginalization increases stress and depression (Chou & Ching, 2014; Ching et al., 2016).

Moderation and Demographic Influences - Moderation analyses highlight the complex interplay between individual dispositions and contextual variables. Openness buffered depression risk more strongly among At-Risk students, suggesting that flexibility and openness to new experiences may mitigate vulnerability. Age and degree status also shaped depression outcomes, with older and degree-seeking students more likely to be at risk, potentially reflecting greater academic and social pressures. Meanwhile, stronger Chinese language ability emerged as protective, echoing Hu et al. (2022), who identified language competence as a key predictor of international students' adjustment.

Contribution to the Literature - This study builds on prior analyses of the datasets published in 2014, 2016,

and 2025, adding a novel person-centered lens. Whereas earlier studies documented stressors, scale validation, and mediating effects of self-confidence and self-actualization (Chang & Ching, 2025), the present findings reveal latent subgroups that vary in both risk and protective factors. Methodologically, this shift to LPA demonstrates the value of person-centered models for uncovering hidden heterogeneity and informing targeted interventions.

5. Conclusions

The present study underscores that international students in Taiwan are not a homogeneous population. Instead, distinct depression-risk profiles emerge, shaped by differences in personality, acculturation strategies, and demographic characteristics. At-Risk students face elevated depressive symptoms, higher neuroticism, and greater endorsement of marginalization, while Well-Adjusted students demonstrate resilience through extraversion, conscientiousness, and integration strategies. These findings highlight the need for universities to identify and support vulnerable subgroups with tailored interventions. More broadly, the study illustrates the utility of person-centered approaches in advancing our understanding of international student mental health and adaptation.

5.1 Practical Implications

This study's results have implications for institutional policy and practice regarding the care of international students. While there is often a relationship between age and maturity, findings indicated that older students reported greater depressive symptoms. The changes with older students may reflect that there are more responsibilities associated with age (childcare, financial responsibilities, family considerations, academic workload). There are also higher chances of finding students older than 30 years of age and pursuing graduate-level studies; where older graduate students may perceive themselves comparatively disadvantaged by classmates, who have long ago completed their degrees. Given these potential disadvantages, institutions of higher education should consider ways to provide support that reflect the experiences of mature international students and/or graduate studies students, specifically career services, financial aid services, and peer mentors or peer support networks providing accountability with an established group of students to lessen the individual feeling of isolation and "falling behind."

As expected, students enrolled in degree programs, as opposed to short-term exchange programs, had an increased risk relative to long-term exchange students. Short-term students may in fact be "testing the waters" in terms of study abroad semester, while degree students have invested time, resources, and emotional commitment into their studies. There are considerable implications for degree students regarding their future academic and professional paths if they do not succeed in Taiwan. While it is unlikely that institutions can provide longitudinal support for degree students who are less than successful, considering long-term support structures (beyond just pre-orientation orientation sessions) to support ongoing academic, cultural or psychological needs by providing mentorship (i.e., paired with senior international student), sustained access to mental health care (if need) and community integration or community building opportunities for the duration of individuals' degree program is even more critical.

Language ability was another protective factor, although Taiwan has made significant investments into internationalizing higher education there is still a large reliance on course instruction being delivered primarily in Mandarin Chinese, limiting full participation in the classroom by students with lower language ability levels. Future studies should consider expanding language support (e.g., intensive Mandarin courses, conversation partners with local students, and bilingual academic material) because funding language development ultimately supports student learning within the classroom, fosters belonging and reduces students at risk of marginalization.

Moreover, the moderation results also point to the value of using screening instruments as part of international student services. Personality measures, such as the Big Five, can help identify students who may be

more vulnerable to depression risk. For example, high neuroticism consistently predicted greater vulnerability, whereas extraversion, agreeableness, and conscientiousness were associated with resilience. Similarly, students reporting higher marginalization in their acculturation strategy were significantly more likely to fall into the At-Risk profile. By integrating brief, validated personality and acculturation surveys during orientation or early in the semester, universities could flag students who may require additional support. Importantly, such tools should not be used for labeling but rather as diagnostic aids to channel resources, such as counseling, peer mentorship, or language and cultural integration programs, to students most at risk. In turn, this proactive approach would allow institutions to allocate limited resources more efficiently and increase the likelihood of successful adjustment for international students.

Overall, these key takeaways demonstrate that institutions need to create and enhance multi-faceted systems of support to assist students overcoming many varied challenges faced during study abroad experiences. Alternative and supportive approaches for students who are older, degree seeking and students with limited language proficiencies could reduce risk of depressed and improve students' ability to be resilient. More holistically, the results of this study could support the argument that for internationalization to have an impact, financial investments in student emotional well-being are equally critical, in order for students to become integrated into the academic community.

5.2 Limitations and Future Recommendations

Several limitations should be acknowledged. First, the data were collected in the pre-COVID period (2013–2014). Although the findings remain highly relevant as a baseline, future studies should examine whether similar profiles emerge in post-pandemic contexts where stressors and coping resources have shifted. Second, the cross-sectional design precludes causal inference; longitudinal studies are needed to track profile stability and transitions over time. Third, the dataset relied on self-reported measures, which may be subject to response biases. Incorporating mixed-method approaches could deepen the interpretation of profile characteristics. Finally, the study was conducted in Taiwan, and findings may not generalize across different cultural or institutional settings. Future research should apply similar LPA models in other East Asian and global contexts to explore cross-national differences. Future recommendations include developing early identification tools for At-Risk students, integrating personality and acculturation assessments into orientation programs, and designing language and cultural support systems that reduce marginalization. Moreover, interventions that foster openness, resilience, and cross-cultural integration may help buffer depression risk and enhance student well-being.

AI Declaration - The authors declare that AI tools, including Wordtune and ChatGPT, were used to polish the English text of this manuscript. These tools assisted in grammar, style refinement, and clarity of expression. The authors takes full responsibility for the content, interpretation, and accuracy of the paper.

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