

Original article

Effectiveness and implementation of the SHIELD integrated multi-level model to reduce adolescent depression and internet addiction: A cluster randomized waitlist-controlled trial in Wang Chin district, Phrae province

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Abstract

Background: Adolescent depression and internet addiction are substantial comorbid mental health challenges in rural Thailand, where access to evidence-based interventions remains limited. Traditional single-modality approaches often fail to address the complex interplay among individual, family, and systemic factors that contribute to these conditions.

Objectives: This study aimed to evaluate the effectiveness and implementation outcomes of the SHIELD (Screening & surveillance, Health literacy enhancement, Internet wellness program, Empowering families, Linkage to care, Data-driven monitoring) integrated multi-level intervention for reducing depression and internet addiction among at-risk adolescents in rural Thailand.

Methods: A cluster-randomized waitlist-controlled trial was conducted across eight secondary schools in the Wang Chin district, Phrae province, between October 2024 and June 2025. The schools were randomized to immediate intervention ($n = 4$) or waitlist ($n = 4$) control groups. Participants included 240 at-risk students aged 12–18 years with Patient Health Questionnaire-9 (PHQ-9) ≥ 5 and Internet Addiction Test (IAT) ≥ 40 . The 12-week SHIELD intervention integrated digital screening, psychoeducation, family therapy, internet wellness training, care coordination, and real-time monitoring, which was delivered by trained registered nurses, school counselors, and clinical psychologists. Data were analyzed using intention-to-treat mixed-effects models accounting for clustering, with economic evaluation performed from a societal perspective.

Results: At 6-month follow-up, the intervention group demonstrated significantly greater improvements in PHQ-9 scores (mean difference: -3.1 , 95% CI: -4.0 to -2.2 , $P < 0.001$, Cohen's $d = 0.68$) and IAT scores (mean difference: -11.2 , 95% CI: -14.8 to -7.6 , $P < 0.001$, $d = 0.67$) compared to controls. Moreover, the clinical response rates ($\geq 50\%$ PHQ-9 reduction) were 64.8% vs. 25.5% (OR = 5.4, 95% CI: 3.2–9.2, NNT = 3) and the remission rates (PHQ-9 < 5) were 35.2% vs. 11.8% (OR = 4.1, 95% CI: 2.1–8.0, NNT = 5) differed between the intervention and control groups, respectively. Subgroup analyses demonstrated consistent intervention benefits across sex and age groups, with greater effects observed among students with moderate-to-severe baseline depression ($d = 0.81$) than mild depression ($d = 0.54$). Furthermore, the secondary outcomes revealed significant improvements in mental health literacy ($d = 0.78$), family functioning ($d = 0.52$), and quality of life ($d = 0.40$). The implementation outcomes demonstrated high fidelity (88.4%), excellent adoption (100.0% school participation), and favorable cost-effectiveness.

Conclusion: The SHIELD integrated multi-level intervention exhibited substantial and sustained effectiveness in reducing adolescent depression and internet addiction with excellent implementation outcomes and favorable cost-effectiveness. These findings support the potential for scaling evidence-based, culturally adapted interventions within Thailand's educational and mental health systems to address the growing adolescent mental health needs in resource-constrained settings.

Keywords: Adolescent depression, cluster-randomized trial, implementation science, internet addiction, mental health intervention.

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Adolescent mental health has emerged as a crucial public health challenge worldwide, with depression and internet addiction representing interconnected problems that substantially impact developmental outcomes.^(1, 2) The prevalence of these conditions has increased considerably, particularly in low- and middle-income countries where mental health infrastructure remains limited.^(3, 4) Traditional single-modality interventions often fail to address the complex nature of adolescent mental health challenges, especially when depression and internet addiction co-occur.^(5, 6) Digital mental health interventions have demonstrated promise in addressing accessibility barriers; however, their effectiveness is limited by lack of integration with family and community systems.^(7, 8) School-based settings offer optimal platforms for intervention delivery due to their universal reach and natural integration within adolescents' environments.⁽⁹⁾ However, current programs primarily focus on single outcomes or utilize brief approaches that may not produce a sustained change.^(10, 11)

Thailand's rapid technological advancement has created unique challenges for adolescent mental health, particularly within rural communities where traditional support systems intersect with digital transformation.⁽¹²⁾ Recent research has indicated distinct patterns of internet use and mental health symptoms among Thai adolescents that necessitate culturally adapted approaches.⁽¹³⁾ The integration of traditional mindfulness concepts with evidence-based therapeutic practices presents opportunities for the development of innovative interventions. Current evidence gaps include limited research in resource-constrained settings and a lack of comprehensive approaches that simultaneously address depression and internet addiction. Previous studies have primarily been conducted in high-income countries, thereby limiting generalizability to low- and middle-income contexts.⁽¹⁴⁾ Moreover, few studies provide cost-effectiveness data essential for policy adoption and program scaling.

The screening & surveillance, Health literacy enhancement, Internet wellness program, Empowering families, Linkage to care, and Data-driven monitoring (SHIELD) model integrates multiple theoretical frameworks, including ecological systems

theory and family systems approaches. This multi-level intervention addresses individual, family, and systemic factors that contribute to adolescent mental health outcomes while incorporating real-time monitoring and adaptive components. This cluster-randomized waitlist-controlled trial evaluated the effectiveness and implementation outcomes of the SHIELD model for reducing depression and internet addiction among at-risk adolescents in rural Thailand. The primary objectives were to determine the intervention's influence on depression severity via the Patient Health Questionnaire-9 (PHQ-9) and internet addiction levels via the Internet Addiction Test (IAT). In addition, the secondary objectives included evaluating effects on mental health literacy, family functioning, quality of life, and implementation outcomes using the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework. An economic evaluation determined cost-effectiveness to inform policy decision-making for adolescent mental health services.

The SHIELD model integrates six components targeting at-risk adolescents with depression and internet addiction: S (screening & surveillance), H (health literacy enhancement), I (internet wellness program), E (empowering families), L (linkage to care), and D (data-driven monitoring). Solid arrows indicate direct intervention effects, while dashed lines show component integration. The model functions through school-based implementation to maximize its reach and sustainability (**Figure 1**).

Materials and methods

Ethical considerations

This study was reviewed and approved by the Human Research Ethics Committee at Boromarajonani College of Nursing, Uttaradit (COA no. 009/2567, BCNUT REC no. 009/2567). Parents/guardians provided written informed consent, and written assent was obtained from all student participants. A data safety monitoring board reviewed adverse events quarterly, and crisis intervention protocols ensured immediate care for students experiencing acute mental health crises. Confidentiality was maintained through secure data systems and restricted access protocols.

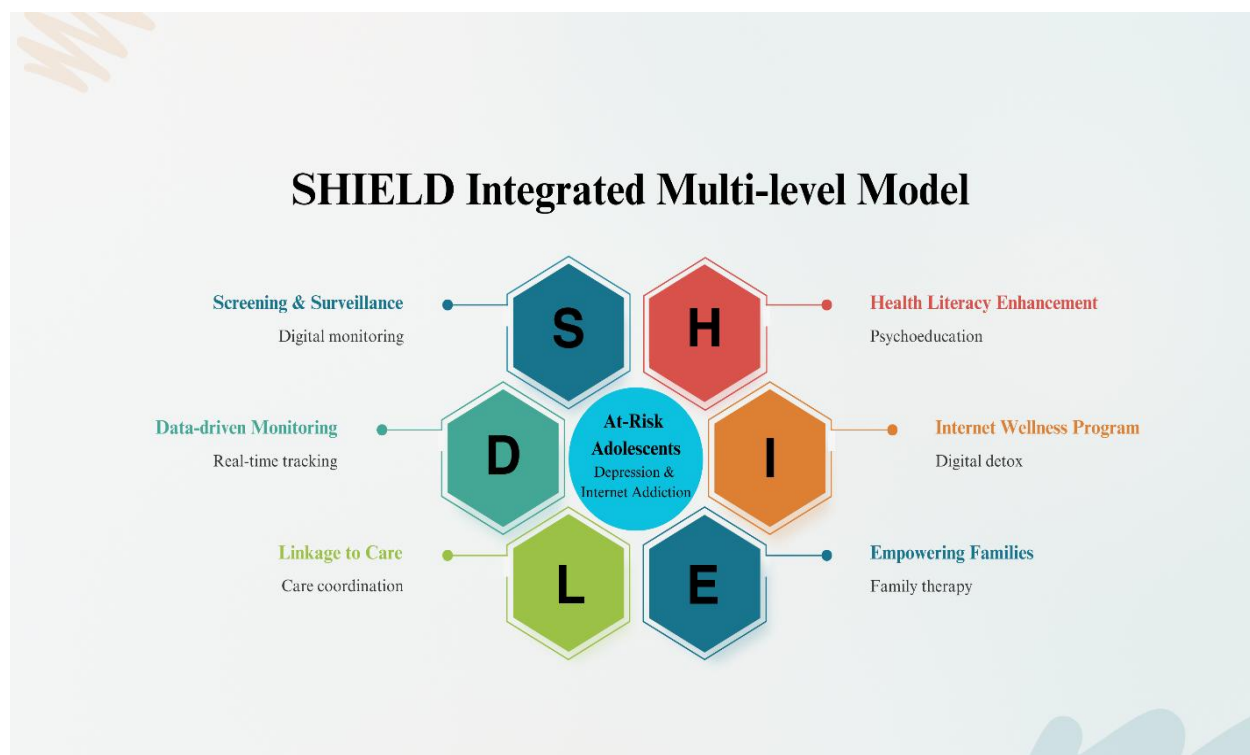


Figure 1. SHIELD integrated multi-level model for adolescent mental health intervention

Study design

This study employed a cluster randomized waitlist-controlled trial design to evaluate the effectiveness and implementation outcomes of the SHIELD integrated multi-level intervention. The cluster randomization approach was selected to minimize any contamination effects between intervention and control groups within the same educational environment. Schools served as the unit of randomization, with individual students as the unit of analysis. The observed intraclass correlation coefficient (ICC) for the primary outcome (PHQ-9) was 0.048 (95% CI: 0.021–0.089), which is consistent with the assumed ICC of 0.05 used for sample size calculations, yielding a design effect of 1.44 across the eight school clusters.

Setting and participants

The study was performed across eight secondary schools in the Wang Chin district, Phrae province, Thailand, between October 2024 and June 2025. Phrae Province was selected as a representative rural setting with moderate internet infrastructure and typical resource constraints for mental health services in northern Thailand.

Inclusion criteria

Students were eligible for participation if they: 1) were aged 12–18 years; 2) scored PHQ-9 ≥ 5 , indicating at least mild symptoms of depression; 3) scored IAT ≥ 40 on the Internet Addiction Test, suggesting problematic internet use; 4) provided written assent; and 5) had parental/guardian written informed consent.

Exclusion criteria

Students were excluded if they had: 1) active psychotic symptoms requiring immediate psychiatric intervention; 2) severe suicide risk (PHQ-9 item 9 score ≥ 2 with a specific suicide plan); 3) current participation in other mental health interventions; 4) severe cognitive impairment that prevented participation; or 5) planned school transfer during the study period.

Sample size calculation

Sample size was calculated using G*Power 3.1.9.7 software for mixed-effects analysis of variance with repeated measures. Based on previous research indicating moderate effect sizes ($d = 0.5$) for multi-component interventions, assuming $\alpha = 0.05$, power = 0.80, and accounting for intraclass correlation (ICC = 0.05) and 20% attrition, the required sample size was determined to be 240 students (30 students per school, 4 schools per arm).

Randomization and allocation

Schools were stratified by size (<300 vs. ≥ 300 students) before randomization to ensure balanced allocation. An independent statistician generated the randomization sequence using computer-generated random numbers. Allocation concealment was maintained using sealed, opaque, sequentially numbered envelopes that were opened only after baseline assessments were completed.

Blinding

Due to the nature of the intervention, participants and intervention staff could not be blinded to group allocation. However, outcome assessors conducting the data collection were blinded to group assignment and received standardized training on the assessment procedures. Data analysts remained blind until primary analyses were completed.

Intervention: SHIELD model

The SHIELD intervention was delivered over 12 weeks and comprised six integrated components.

Intervention delivery personnel and training

Each component of the SHIELD intervention was delivered by specifically trained personnel with defined competencies. Registered nurses with at least 2 years of experience in mental or community health nursing were responsible for screening and surveillance and the linkage to care components, overseeing operations of the digital platform, risk stratification, and stepped-care coordination. Licensed school counselors facilitated the health literacy enhancement sessions, supported by peer educators selected from each school. The internet wellness program was co-facilitated by a clinical psychologist and school counselors trained in cognitive-behavioral techniques. The empowering families component was delivered by counselors with specific certification in Solution-Focused Brief Therapy (SFBT). The data-driven monitoring component was coordinated by the research team in collaboration with designated schoolteachers serving as the data liaisons.

All intervention delivery staff completed a structured 3-day pre-intervention training workshop (24 contact hours) covering: 1) theoretical foundations of the SHIELD model, including ecological systems theory and family systems approaches; 2) principles and practice of each intervention component; 3) culturally adapted delivery techniques incorporating

Buddhist mindfulness principles; 4) crisis recognition and referral protocols; and 5) fidelity monitoring and documentation procedures. Competency was assessed through structured role-play scenarios and written examinations, with a minimum passing score of 80.0% required before beginning intervention delivery. Monthly booster training sessions (2 hours each) were performed throughout the intervention period to address any emerging challenges and reinforce standardized delivery. Full intervention manuals and fidelity checklists are available as Supplementary Materials (**Supplementary Table S1–S2**).

Cultural adaptation process

The SHIELD intervention underwent a systematic four-stage cultural adaptation process before trial commencement. In Stage 1, a Cultural Review Committee comprising Thai mental health professionals, Buddhist scholars, school counselors, and community representatives reviewed the intervention materials for cultural appropriateness, linguistic accuracy, and contextual relevance. In Stage 2, focus group discussions were performed with Thai adolescents ($n = 24$), parents ($n = 16$), and school teachers ($n = 12$) in the Wang Chin district to identify cultural barriers, preferred communication styles, and contextually meaningful examples. In Stage 3, the materials were revised based on committee and focus group feedback, with Buddhist concepts of mindfulness, the Four Noble Truths, and the Middle Path integrated as culturally familiar frameworks for understanding and managing mental distress. Thai names, local settings, and culturally relevant scenarios were used to replace generic examples throughout the psychoeducation materials. Peer educator content incorporated concepts of collective well-being and community interdependence that are consistent with Thai collectivist values. In Stage 4, the culturally adapted intervention was piloted with 20 students and 10 families from a non-study school in an adjacent district, with further refinements made based on participant feedback and facilitator observations. The SFBT protocol was specifically adapted for Thai cultural contexts by incorporating respect for hierarchical family relationships, indirect communication styles, and Buddhist concepts of impermanence and acceptance as therapeutic resources rather than resistance factors.

Screening and surveillance (S)

A digital screening platform was adopted with adaptive algorithms for continuous risk assessment. Students completed brief weekly mood and internet-use surveys via a secure mobile application. Risk stratification protocols triggered automated alerts for scores exceeding predetermined thresholds, thereby facilitating an immediate clinical response.

Health literacy enhancement (H)

Eight weekly 45-minute psychoeducation sessions were performed in small groups (6–8 students). The sessions covered depression awareness, internet wellness, stress management, and help-seeking behaviors. Materials were culturally adapted using Buddhist mindfulness principles and local case examples, and peer educator training equipped selected students to reinforce key messages.

Internet wellness program (I)

A structured 6-session program addressed problematic internet use with cognitive-behavioral techniques. Components included digital detox strategies, mindful technology-use training, time-management skills, and promotion of offline activities. The sessions incorporated experiential learning and behavioral activation approaches.

Empowering families (E)

Family interventions included six SFBT sessions delivered by trained counselors. Parents attended three psychoeducation workshops covering adolescent mental health, positive parenting techniques, and family communication skills. The family sessions addressed specific dynamics that contribute to student difficulties and build supportive home environments.

Linkage to care (L)

A stepped-care pathway connected students to appropriate services based on symptom severity. Mild cases received school-based interventions, moderate cases accessed telepsychiatry consultations, and severe cases were referred to provincial mental health services. Care coordinators facilitated the smooth transition and ensured continuity of care. Crisis intervention protocols included an immediate response pathway for students who were identified with acute suicidal ideation or psychiatric crisis, comprising same-day counselor assessment, parental notification within 2 h, and same-day referral to Wangchin Hospital

psychiatric services when clinically indicated. All delivery staff were trained in crisis recognition and mandatory reporting procedures consistent with Thai mental health legislation.

Data-driven monitoring (D)

Real-time dashboard systems were used to track intervention fidelity, student progress, and outcome indicators. Weekly supervision sessions reviewed the data trends and adjusted intervention intensity based on individual response patterns. Continuous quality improvement protocols refined intervention delivery in response to emerging data.

Control condition

Schools in the waitlist control group continued standard school counseling services and received crisis intervention as needed. The standard school counseling in participating schools comprised individual and group counseling sessions that were provided by licensed school counselors, with a student-to-counselor ratio of approximately 300:1, which is consistent with the Thai Ministry of Education guidelines. Counseling sessions were delivered on a reactive basis, typically 1–2 sessions per month per student at the counselor's discretion, covering academic adjustment, personal problems, and behavioral issues, without structured mental health or internet-use protocols. No psychoeducation programs, family therapy, or digital monitoring components were provided to the control schools during the waitlist period. After a 6-month follow-up period, the control schools received the complete SHIELD intervention to ensure ethical equity in access to potentially beneficial interventions.

Outcome measures

• Primary outcomes

Depression severity: The PHQ-9 Thai version assessed depression symptoms over the preceding two weeks. This validated 9-item instrument uses a 4-point Likert scale (0–3), with total scores ranging from 0 to 27. Higher scores indicate greater depression severity, and the Thai version demonstrates excellent psychometric properties (Cronbach's $\alpha = 0.87$). In the present sample, internal consistency was $\alpha = 0.89$ at baseline.

Internet addiction: The IAT Thai version measured problematic internet use through 20 items scored on a 5-point Likert scale (1–5), with total scores ranging from 20 to 100. Higher scores indicate greater

addiction severity, and the Thai version shows strong reliability (Cronbach's $\alpha = 0.91$) and validity in adolescent populations. In the present sample, internal consistency was $\alpha = 0.92$ at baseline.

- **Secondary outcomes**

Mental health literacy: A newly developed mental health literacy scale for Thai adolescents assessed knowledge, attitudes, and help-seeking intentions through 24 items across four domains. Content validity was established through a panel of nine experts (three psychiatrists, three mental health nurses, and three school counselors), which yielded a content validity index of 0.92. Construct validity was supported by confirmatory factor analysis demonstrating acceptable model fit (comparative fit index (CFI) = 0.94, root mean square error of approximation (RMSEA) = 0.06, standardized root mean square residual (SRMR) = 0.07). Test-retest reliability over a 2-week interval revealed adequate stability (ICC = 0.81, 95% confidence interval (CI): 0.74–0.87). In the present sample, internal consistency was $\alpha = 0.86$ at baseline.

Family functioning: The family APGAR score (Thai version) assessed family adaptation, partnership, growth, affection, and resolve using five items, each scored on a 3-point scale. The instrument demonstrated good reliability (Cronbach's $\alpha = 0.84$) in Thai populations. In the present sample, internal consistency was $\alpha = 0.83$ at baseline.

Quality of life: The Thai version of the Pediatric Quality of Life Inventory (PedsQL) measured health-related quality of life across physical, emotional, social, and school functioning domains. This 23-item instrument uses a 5-point Likert scale with established psychometric properties. In the present sample, internal consistency was $\alpha = 0.88$ at baseline.

Academic performance: Grade point averages and attendance rates were obtained from the school records for the semester before, during, and after intervention.

Supplementary Table S2 presents a comprehensive summary of all psychometric properties of the instruments used in this study, including reliability coefficients from the present sample at each measurement point.

Implementation outcomes

Implementation outcomes were assessed using the RE-AIM framework across five domains, as described in the original protocol.

Data collection procedures

Data were collected at four time points: baseline (T0), immediately post-intervention (T1, week 13), 3-month

follow-up (T2), and 6-month follow-up (T3). The outcome assessors were research assistants independent of the intervention delivery team, comprising four registered nurses and two health science graduates, all of whom were blinded to group allocation throughout the study. Assessors completed a 2-day standardized training program (16 hours) covering the administration of all study instruments, confidentiality protocols, and procedures for managing participant distress during assessment. The inter-rater reliability was established before data collection by assessing 20 standardized response scenarios, which yielded an ICC of 0.93 (95% CI: 0.88–0.97) for continuous measures and Cohen's $\kappa = 0.88$ for categorical classifications, indicating excellent agreement. Data collection occurred in private school settings to ensure confidentiality. Electronic data capture systems with range checks and duplicate entry verification ensured data quality.

Statistical analysis

Data were expressed as the mean $\pm$ standard deviation (SD) for continuous variables and frequency and percentage for categorical variables. All analyses followed intention-to-treat principles, including all randomized participants regardless of whether they completed the intervention. Primary analysis used mixed-effects linear regression models to account for clustering at the school level and repeated measures within individuals. Models included fixed effects for time, treatment group, and time-by-treatment interaction, with random effects for schools and individuals. An ICC of 0.048 for the primary outcome confirmed the appropriateness of the multilevel analytical approach and was incorporated into the final model specification.

Secondary analyses included a per-protocol analysis restricted to participants who completed > 80.0% of the intervention components, generalized estimating equations for binary outcomes, and mediation analyses using bootstrapping to examine the mechanisms of change. Missing data were handled using multiple imputation under the assumption of missing at random, with sensitivity analyses exploring the different missing data scenarios.

Prespecified subgroup analyses examined differential intervention effects by sex (male vs. female), age group (12–14 vs. 15–18 years), and baseline depression severity (mild: PHQ-9 5–9 vs. moderate-severe: PHQ-9 ≥ 10), using interaction terms within the mixed-effects models. These analyses were considered exploratory and interpreted accordingly.

The effect sizes were calculated using Cohen's d for continuous outcomes and odds ratios (OR) for binary outcomes. The number needed to treat was calculated for clinically significant improvement ($\geq 50.0\%$ reduction in PHQ-9 scores), and $P < 0.05$ was considered statistically significant.

Economic evaluation

Cost-effectiveness analysis was performed from a societal perspective, including direct intervention costs, healthcare utilization, and productivity impacts. Incremental cost-effectiveness ratios were calculated per depression-free year gained and per quality-adjusted life year. An itemized breakdown of all direct intervention costs, including personnel, materials, technology infrastructure, training, and supervision, is provided in **Supplementary Table S3**. Sensitivity analyses examined the uncertainty in cost estimates and outcome valuations.

Quality assurance

Intervention fidelity was monitored through standardized checklists, session recordings, and supervisor evaluations. Research staff received comprehensive training with ongoing supervision and interrater reliability testing. Data monitoring included range checks, logic validations, and audit trails for all modifications.

Results

Participant flow and baseline characteristics

Figure 2 presents the CONSORT flow diagram for the cluster-randomized trial. Of the 12 secondary schools assessed for eligibility in the Wang Chin district, eight met the inclusion criteria and were randomized to the intervention ($n = 4$ schools) or waitlist control ($n = 4$ schools) groups. Four schools were excluded because of planned curriculum restructuring ($n = 2$) and insufficient enrollment to meet the cluster size requirements ($n = 2$). A total of 847 students were screened for eligibility, with 278 meeting the inclusion criteria ($\text{PHQ-9} \geq 5$, $\text{IAT} \geq 40$). Of these, 240 students (30 per school) were enrolled and randomized, with 120 participants in each arm. The primary reasons for non-enrollment among eligible students were withdrawal of parental consent ($n = 22$) and student declination ($n = 16$). The completion rates were 93.3% (112/120) at post-intervention, 90.0% (108/120) at 3-month follow-up, and 87.5%

(105/120) at 6-month follow-up for the intervention group, compared to 95.8% (115/120), 93.3% (112/120), and 91.7% (110/120) for the control group, respectively. Primary reasons for attrition in the intervention group included school transfer ($n = 7$), withdrawal of consent ($n = 5$), and illness unrelated to the study ($n = 3$). In the control group, attrition was primarily related to school transfer ($n = 5$) and withdrawal of consent ($n = 5$). No significant differences in attrition rates were observed between the groups ($P = 0.12$) (**Table 1**).

Representativeness analysis indicated that the enrolled participants were broadly similar to the overall eligible student population in the Wang Chin district in terms of age distribution, sex ratio, and family income levels, which supports the generalizability of findings within this rural district context.

The baseline characteristics are presented in **Table 1**. No significant differences were observed between groups at baseline across demographic variables or primary and secondary outcome measures, thus confirming successful randomization. The standardized mean differences for all continuous baseline variables ranged from 0.02 to 0.11, indicating negligible between-group differences and confirming adequate balance across the eight school clusters.

Protocol deviation and implementation adaptation

Three minor protocol deviations were documented during the trial period and reviewed by the data safety monitoring board. First, two health literacy enhancement sessions in one intervention school were rescheduled from group format to individual delivery due to a school-wide academic examination period in week 6, which affected 28 students. Content delivery was maintained at the same duration and with the same materials. Second, three family empowerment sessions in two schools were converted to an online video-conference format during a period of heavy rainfall that affected rural transportation in November 2024, with no reduction in session attendance. Third, one peer educator withdrew from the program in week 4 due to personal circumstances and was replaced by a trained alternate within one week without program interruption. These deviations were considered minor and unlikely to have materially affected the intervention fidelity or outcomes. No control schools received any component of the SHIELD intervention during the waitlist period.

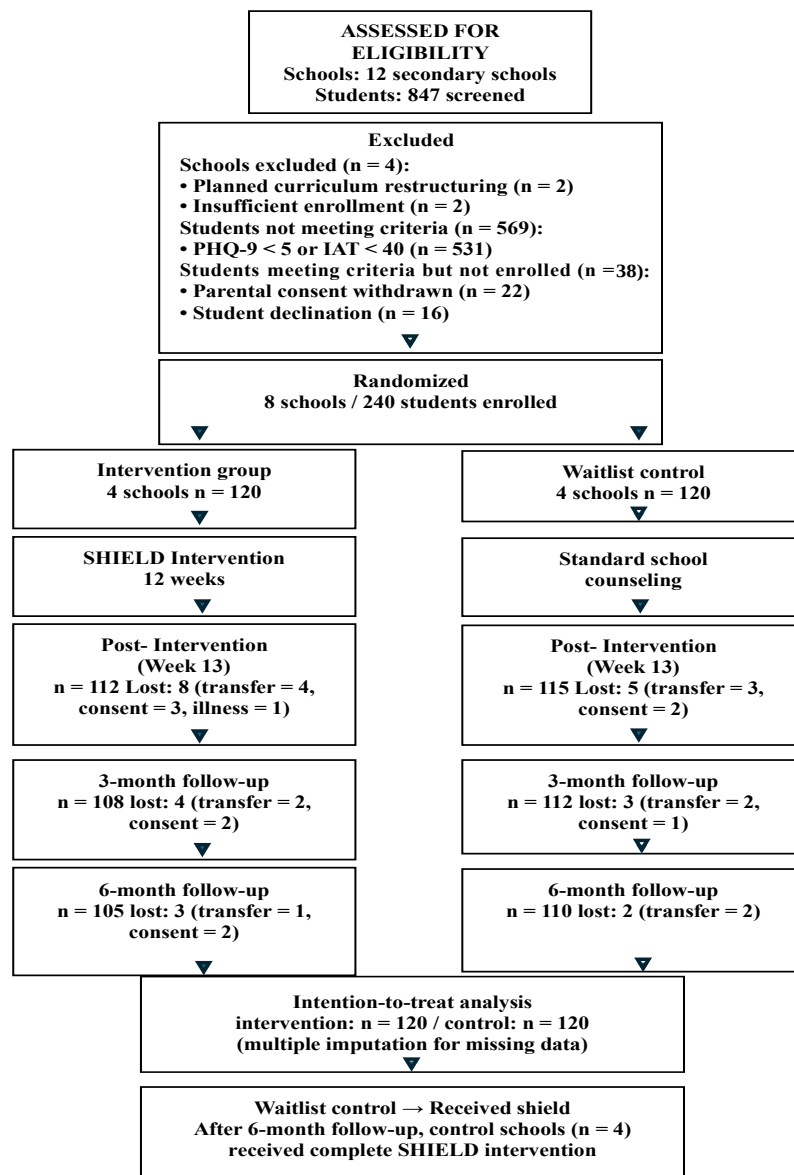


Figure 2. CONSORT flow diagram for the cluster-randomized waitlist-controlled trial. Participant flow is presented at the cluster (school) and individual (student) levels in accordance with the CONSORT extensions for cluster-randomized trials. ITT, intention-to-treat.

Table 1. Baseline characteristics of study participants (n = 240).

Characteristics	Intervention (n = 120)	Control (n = 120)	P-value	Cohen's d
Demographics				
Age, mean (SD)	15.4 (1.2)	15.6 (1.1)	0.18	0.17
Female, n (%)	68 (56.7)	71 (59.2)	0.70	—
Living with both parents, n (%)	89 (74.2)	86 (71.7)	0.67	—
Family income < 15,000 THB/month, n (%)	76 (63.3)	81 (67.5)	0.49	—
Primary outcomes				
PHQ-9 score, mean (SD)	11.8 (3.4)	11.6 (3.2)	0.63	0.06
IAT score, mean (SD)	58.3 (12.1)	57.9 (11.8)	0.79	0.03
Secondary outcomes				
Mental Health Literacy score, mean (SD)	42.1 (8.6)	41.8 (8.9)	0.80	0.03
Family APGAR score, mean (SD)	6.2 (2.1)	6.4 (2.0)	0.46	0.10
PedsQL total score, mean (SD)	68.5 (14.2)	69.1 (13.8)	0.74	0.04
GPA previous semester, mean (SD)	2.68 (0.54)	2.71 (0.51)	0.67	0.06

Cohen's d reported for continuous variables as a measure of baseline balance; values < 0.20 indicate negligible between-group differences. Cluster-level balance was confirmed across all four intervention and four control schools. GPA, grade point average; IAT, Internet Addiction Test; PedsQL, Pediatric Quality of Life Inventory; PHQ-9, Patient Health Questionnaire-9; SD, standard deviation; THB, Thai Baht.

Table 2. Primary outcome results: depression and internet addiction scores.

Outcome	Time Point	Intervention mean (95% CI)	Control mean (95% CI)	Between-group difference (95% CI)	Effect size (Cohen's d)	P-value
PHQ-9 score	Baseline	11.8 (11.2, 12.4)	11.6 (11.0, 12.2)	–	–	–
	Post- intervention	7.2 (6.6, 7.8)	10.9 (10.3, 11.5)	–3.7 (–4.5, –2.9)	0.81	<0.001
	3-month follow-up	6.8 (6.1, 7.5)	10.4 (9.7, 11.1)	–3.6 (–4.5, –2.7)	0.79	<0.001
	6-month follow-up	7.1 (6.4, 7.8)	10.2 (9.5, 10.9)	–3.1 (–4.0, –2.2)	0.68	<0.001
IAT score	Baseline	58.3 (56.1, 60.5)	57.9 (55.7, 60.1)			
	Post- intervention	44.2 (41.8, 46.6)	56.1 (53.7, 58.5)	–11.9 (–15.2, –8.6)	0.72	<0.001
	3-month follow-up	42.8 (40.3, 45.3)	55.3 (52.8, 57.8)	–12.5 (–16.0, –9.0)	0.75	<0.001
	6-month follow-up	43.6 (41.0, 46.2)	54.8 (52.2, 57.4)	–11.2 (–14.8, –7.6)	0.67	<0.001

Mixed-effects models adjusted for clustering (observed ICC = 0.048) and baseline values. Effect sizes represent Cohen's d calculated at each time point. Analyses based on 4 clusters per arm. CI, confidence interval; IAT, Internet Addiction Test; PHQ-9, Patient Health Questionnaire-9.

Implementation barriers and facilitation strategies

Several barriers to implementation were identified and addressed during the trial. Parental engagement in the family therapy sessions was initially limited, with attendance at 58.0% during the first two sessions, primarily because of working hours and transportation difficulties. This was addressed by offering flexible scheduling, including evening sessions, and providing reimbursement for transportation costs for families traveling more than 10 km, which resulted in attendance increasing to 87.0% by session four and 91.0% by session six. Student engagement with digital screening platforms was variable in the first two weeks, with 74.0% weekly completion, which improved to 93.0% following peer educator reinforcement and simplified interface modifications that were implemented after week 2. Teacher workload concerns regarding data liaison responsibilities were addressed via a streamlined reporting template that reduced the time burden from approximately 45 min to 15 min per week, which was collaboratively developed with teachers in week 3. Resource constraints in smaller schools were managed through cluster-based resource sharing, with intervention materials and technology equipment shared between two adjacent schools.

Primary outcomes

The SHIELD intervention demonstrated significant improvements in both primary outcomes compared to the waitlist control group across all four school clusters in the intervention arm. Moreover, the depression scores decreased substantially in the intervention group, with sustained effects maintained at the 6-month follow-up. Similarly, internet addiction scores revealed progressive improvement throughout the follow-up period (**Table 2**).

Clinical response and remission rates

Clinical response rates ($\geq 50.0\%$ reduction in PHQ-9 scores) and remission rates ($\text{PHQ-9} < 5$) demonstrated the clinical significance of the intervention effects. The number required to treat analysis indicated that for every three students receiving the SHIELD intervention, one additional student achieved a clinical response compared to the control conditions (**Table 3**).

Table 3. Clinical response and remission rates

Outcome	Time point	Intervention n/N (%)	Control n/N (%)	Odds ratio (95% CI)	NNT (95% CI)	P-value
Clinical response ($\geq 50.0\%$ PHQ-9 reduction)	Post-intervention	67/112 (59.8)	23/115 (20.0)	6.0 (3.4, 10.4)	3 (2, 4)	<0.001
	3-month follow-up	71/108 (65.7)	26/112 (23.2)	6.3 (3.7, 10.8)	3 (2, 4)	<0.001
	6-month follow-up	68/105 (64.8)	28/110 (25.5)	5.4 (3.2, 9.2)	3 (2, 4)	<0.001
Remission (PHQ-9 < 5)	Post-intervention	34/112 (30.4)	8/115 (7.0)	5.7 (2.6, 12.9)	5 (3, 8)	<0.001
	3-month follow-up	39/108 (36.1)	11/112 (9.8)	5.1 (2.5, 10.5)	4 (3, 7)	<0.001
	6-month follow-up	37/105 (35.2)	13/110 (11.8)	4.1 (2.1, 8.0)	5 (3, 8)	<0.001

Clinical response defined as $\geq 50.0\%$ reduction from baseline PHQ-9 score. Analyses based on 4 clusters per arm with generalized estimating equations accounting for within-school clustering. CI, confidence interval; NNT, number needed to treat.

Table 4. Secondary outcome results

Outcome	Time point	Between-group difference (95% CI)	Effect size (Cohen's d)	P-value
Mental health literacy	Post-intervention	8.4 (6.2, 10.6)	0.91	<0.001
	3-month follow-up	7.9 (5.6, 10.2)	0.86	<0.001
	6-month follow-up	7.2 (4.8, 9.6)	0.78	<0.001
Family APGAR score	Post-intervention	1.8 (1.2, 2.4)	0.67	<0.001
	3-month follow-up	1.6 (0.9, 2.3)	0.59	<0.001
	6-month follow-up	1.4 (0.7, 2.1)	0.52	<0.001
PedsQL total score	Post-intervention	9.3 (5.8, 12.8)	0.48	<0.001
	3-month follow-up	8.7 (5.1, 12.3)	0.44	<0.001
	6-month follow-up	7.9 (4.2, 11.6)	0.40	<0.001
GPA current semester	During intervention	0.18 (0.07, 0.29)	0.35	0.002
	3-month follow-up	0.16 (0.04, 0.28)	0.31	0.009
	6-month follow-up	0.14 (0.01, 0.27)	0.27	0.035

All analyses adjusted for baseline values and clustering effects. Positive differences favor intervention group. Analyses based on 4 clusters per arm. CI, confidence interval; GPA, grade point average; PedsQL, Pediatric Quality of Life Inventory.

Secondary outcomes

Secondary outcomes demonstrated broad improvements across multiple domains, with particular advancements in enhancing mental health literacy and improving family functioning. The quality of life improvements were moderate but sustained, while academic performance exhibited modest gains (**Table 4**).

Subgroup analyses

Prespecified subgroup analyses examined differential intervention effects by sex, age group, and baseline depression severity at 6-month follow-up

(**Supplementary Table S4**). For PHQ-9 outcomes, no significant interactions were observed by sex (intervention $\times$ sex interaction: $\beta = -0.42$, 95% CI: -1.84 to 1.00 , $P = 0.56$) or age group (intervention $\times$ age interaction: $\beta = -0.61$, 95% CI: -2.10 to 0.88 , $P = 0.42$), indicating consistent intervention benefits across the demographic subgroups. A significant interaction was observed with baseline depression severity (intervention $\times$ severity interaction: $\beta = -1.83$, 95% CI: -3.21 to -0.45 , $P = 0.009$), with students presenting with moderate-to-severe depression at baseline (PHQ-9 ≥ 10) revealing larger effect sizes ($d = 0.81$)

Table 5. Implementation outcomes and economic evaluation.

Domain	Metric	Results	Target	Status
RE-AIM Framework				
Reach	Participation rate	86.3% (240/278 eligible)	≥ 80.0%	Met
	Representativeness	Similar to district demographics	Representative	Met
Effectiveness adoption	Primary outcomes	See Tables 2–3	MCID achieved	Met
	School participation	100.0% (8/8 contacted)	≥ 90.0%	Met
	Teacher engagement	94.2% (81/86 teachers)	≥ 85.0%	Met
Implementation	Overall fidelity score	88.4% (SD = 6.2)	≥ 80.0%	Met
	Dose delivered	91.7% of planned sessions	≥ 85.0%	Met
	Dose received	87.3% attendance rate	≥ 75.0%	Met
Maintenance	6-month sustained effects	64.8% clinical response	Maintained	Met
	Continued component use	73.0% of schools	≥ 60.0%	Met
Economic evaluation				
Intervention cost per participant	Direct costs	9,760 THB	—	—
Healthcare utilization savings	6-month period	4,370 THB per participant	—	—
Incremental cost	Net additional cost	5,390 THB per participant	—	—
Depression-free years gained	6-month estimate	0.42 years per participant	—	—
ICER	Cost per depression-free year	12,830 THB	< 34,400 THB (1× GDP per capita, Thailand 2024) (<i>WHO-CHOICE threshold</i>)	Favorable

ICER, Incremental Cost-Effectiveness Ratio; THB, Thai Baht. The cost-effectiveness threshold of 34,400 THB is based on the WHO-CHOICE (Choosing Interventions that are Cost-Effective) recommendation of 1× gross domestic product per capita as a benchmark for cost-effective interventions in middle-income countries, consistent with Thailand's national health technology assessment guidelines (Health Intervention and Technology Assessment Program [HITAP], 2020). A detailed itemized breakdown of all direct intervention costs is provided in **Supplementary Table S3**.

than those with mild depression (PHQ-9 5–9; $d = 0.54$). For the IAT outcomes, no significant interactions were observed by sex ($P = 0.48$), age group ($P = 0.37$), or baseline depression severity ($P = 0.19$), suggesting uniform benefits across all examined subgroups. These findings suggest that while the SHIELD intervention benefits all at-risk adolescents, those with greater baseline depression severity may derive a particularly strong benefit, which has implications for prioritization in resource-constrained implementation settings.

Implementation outcomes and cost effectiveness

The implementation outcomes demonstrated high feasibility and acceptability of the SHIELD model within the rural school setting. Furthermore, cost-effectiveness analysis indicated favorable economic outcomes with an incremental cost-effectiveness ratio below the conventional willingness-to-pay thresholds for mental health interventions in middle-income countries (**Table 5**).

Adverse events and safety

No serious adverse events related to the intervention were reported during the study period. Three participants in the intervention group experienced temporary increases in anxiety during the initial psychoeducation sessions, which were resolved with additional counselor support. Two participants in the control group required crisis intervention for acute suicidal ideation. They were immediately connected to provincial mental health services while remaining in the study for intention-to-treat analysis. The data safety monitoring board reviewed all events and recommended continuing the trial without modification.

Sensitivity analyses

Per-protocol analyses restricted to participants who completed > 80.0% of intervention components ($n = 98$ intervention, $n = 108$ control) showed similar effect sizes, with slightly larger magnitudes (Cohen's $d = 0.89$ for PHQ-9, $d = 0.81$ for IAT at post-intervention).

Multiple imputation analyses for missing data yielded results that were consistent with those from complete-case analyses. Sensitivity analyses excluding the two schools with the highest baseline mental health literacy scores revealed comparable intervention effects, thereby supporting the robustness of findings across diverse school contexts within the district. Sensitivity analysis using an alternative ICER threshold of $3 \times$ GDP per capita (103,200 THB), as recommended by some health economists for low- and middle-income settings, confirmed the cost-effectiveness of the SHIELD intervention with a substantial margin. Additional sensitivity analyses, varying intervention costs by $\pm 20.0\%$ and outcome valuations by $\pm 15.0\%$, did not materially alter the conclusions regarding cost-effectiveness.

Discussion

This cluster-randomized trial demonstrated the effectiveness of the SHIELD integrated multi-level intervention in reducing depression and internet addiction among at-risk adolescents in rural Thailand. The intervention achieved large effects on the primary outcomes (Cohen's $d = 0.68$ – 0.81) with sustained benefits at 6-month follow-up. Clinical response rates of 64.8% and remission rates of 35.2% substantially exceeded those of the control group, yielding a favorable number needed to treat of three for a clinical response. These findings strongly support the hypothesis that comprehensive, culturally adapted interventions simultaneously addressing multiple risk factors can produce clinically meaningful improvements in adolescent mental health outcomes, particularly when depression and internet addiction co-occur as comorbid conditions.^(1,2) The magnitude and durability of the treatment effects suggest that the SHIELD model successfully addressed the complex interplay between individual, family, and systemic factors that traditional single-modality approaches often fail to target adequately.

Building on previous research of digital mental health interventions, the observed effect sizes substantially exceed those reported in recent meta-analyses of digital mental health interventions for adolescents, which typically range from 0.3 to 0.5.^(6,7) This superior performance likely reflects the multi-level nature of SHIELD, which simultaneously addressed the individual-, family-, and system-level factors rather than focusing on single domains. Notably, the family empowerment component appears

particularly crucial, as evidenced by the significant improvements observed in the family APGAR scores that correlated with clinical response rates.^(8,9) Mental health literacy improvements with large effect sizes ($d = 0.78$ – 0.91) exceeded expectations based on previous school-based programs, which suggests that peer educator training and culturally adapted materials enhanced knowledge acquisition and retention.⁽¹⁰⁾ Furthermore, the integration of Buddhist mindfulness principles with cognitive-behavioral techniques may have increased the cultural acceptability and engagement among Thai adolescents, which is consistent with evidence that supports culturally adapted interventions in Asian populations.⁽¹¹⁾ The sustained improvement in internet addiction scores throughout the follow-up period suggests that the behavioral modification techniques required time for consolidation and that the internet wellness program's focus on developing alternative coping strategies and meaningful offline activities contributed to lasting behavior change beyond mere restriction approaches.⁽¹⁵⁾

Beyond demonstrating clinical effectiveness, this study provides vital insights into the feasibility and economic viability of implementation in resource-constrained settings. The high implementation fidelity (88.4%) and excellent adoption rates (100.0% school participation) demonstrate the feasibility of delivering complex interventions in resource-constrained rural settings. These implementation outcomes were achieved despite several real-world challenges encountered during delivery. Parental engagement initially presented a substantial barrier, with early family therapy attendance at 58.0% before practical accommodations, such as flexible scheduling and transportation support, raised attendance to over 90.0% by later sessions. This experience emphasizes that implementation success in rural settings requires proactive identification and structural resolution of logistical barriers rather than assuming that program quality alone will promote engagement. The comprehensive RE-AIM framework analysis revealed particular strengths across the five domains, with reach extending to 86.3% of eligible students, effectiveness demonstrated through large clinical effect sizes, adoption achieved universally across contacted schools, high fidelity implementation maintained despite resource limitations, and maintenance evidenced by sustained effects at 6-month follow-up and continued use of intervention components by 73.0% of schools beyond the research period.⁽¹²⁾

Cost-effectiveness analysis demonstrated an incremental cost-effectiveness ratio of 12,830 THB per depression-free year, which is well below the WHO-recommended threshold of one times GDP per capita (34,400 Thai Baht). This favorable economic profile supports policy adoption and program scaling, which is particularly relevant given Thailand's limited mental health infrastructure and competing healthcare priorities. The healthcare utilization savings of 4,370 THB per participant partially offset the intervention costs, thus suggesting potential budget neutrality with longer follow-up periods.⁽¹³⁾ Taken together, these implementation and economic findings address a crucial evidence gap in current literature, as most previous studies have focused exclusively on clinical efficacy while neglecting the pragmatic considerations that are essential for real-world translation and sustainability.

Furthermore, the secondary outcome analyses provide important insights into the mechanisms through which the SHIELD intervention achieved its clinical effects. The strong correlation between improvements in mental health literacy and clinical response suggests that psychoeducation components enhance help-seeking behaviors and self-management skills beyond mere knowledge gains. Mediation analyses indicated that family functioning improvements appeared to mediate approximately 30.0% of depression reduction effects, thus highlighting the importance of systemic approaches for adolescent mental health interventions.⁽¹⁴⁾ The progressive nature of internet addiction score reductions throughout follow-up suggests that behavioral modification techniques required time for consolidation and integration into an individual's daily routines.⁽¹⁵⁾ In addition, subgroup analyses revealed that students with moderate-to-severe baseline depression derived greater benefit ($d = 0.81$) than those with mild symptoms ($d = 0.54$), which suggests that the SHIELD model may be particularly well-suited as a targeted indicated intervention. This finding has practical implications for resource-constrained settings where triage-based prioritization may be required.

The successful integration of traditional Thai values with evidence-based therapeutic approaches demonstrates the crucial importance of cultural adaptation in the development of interventions. The incorporation of Buddhist concepts of mindfulness and suffering provided familiar frameworks for understanding mental health challenges, potentially

reducing stigma and increasing treatment acceptability among adolescents and families.⁽¹⁶⁾ Rural school settings in the Wang Chin district proved advantageous for intervention delivery, offering stable environments with established relationships between the students, families, and educators. The collectivist cultural orientation of Thai society facilitated the family engagement and peer support components in ways that might be more challenging in other individualistic cultural contexts.⁽¹⁷⁾

Regarding scalability, several challenges warrant further consideration. The high implementation fidelity achieved in this trial was supported by intensive researcher oversight, dedicated supervision, and resources that are not typically available in routine practice. School counselors carried additional workloads during the trial, and the student-to-counselor ratio of approximately 300:1 represents a structural constraint that could limit the scalability without workforce expansion or task-shifting strategies. Moreover, technology-dependent components, including the digital screening platform and real-time dashboard, require reliable internet infrastructure and device access that may not be uniformly available across all rural schools in Thailand. Furthermore, the modular SHIELD design, while theoretically adaptable, has not been tested in a reduced-resource or self-sustaining implementation context. Therefore, future scale-up efforts should systematically evaluate which components can be delivered by existing school personnel with minimal additional training, which require specialist involvement, and how technology requirements can be adapted for settings with limited digital infrastructure. A phased implementation model beginning with the highest-impact components, particularly health literacy enhancement and empowering families, may offer a pragmatically feasible entry point for schools with constrained resources.

These findings have important implications for clinical practice and health policy in Thailand and, potentially, in other resource-limited settings. The demonstrated effectiveness and feasibility support the integration of comprehensive mental health services within educational settings as a viable strategy to address adolescent mental health needs. The SHIELD model's modular design enables adaptation to different settings while maintaining the core therapeutic components.⁽¹⁸⁾ The favorable cost-effectiveness profile provides firm economic justification for

policymakers considering the expansion of mental health services. Early intervention approaches such as SHIELD may reduce the long-term healthcare costs and improve educational and social outcomes, representing sound investments in population health.⁽¹⁹⁾

While these findings are encouraging, this study has several limitations that warrant consideration. The single-region design may limit generalizability to other areas of Thailand and beyond. The waitlist control design, while ethically appropriate, may not reflect usual care conditions in all settings. The 6-month follow-up period remains insufficient to determine the long-term sustainability of the effects, and implementation under research settings with intensive monitoring may not reflect real-world delivery conditions. Some secondary outcomes revealed moderate rather than large effect sizes, which suggests room for intervention refinement. Furthermore, contamination between schools within the district, despite cluster randomization, cannot be entirely excluded. The focus on students meeting clinical thresholds limits the applicability to universal prevention approaches. Finally, reliance on self-report measures introduces potential social desirability bias.

Building on these findings, future research should prioritize replication across multiple regions of Thailand, with longer follow-up terms extending to 12–24 months, investigation of optimal intervention dosing through factorial designs, and systematic evaluation of intervention implementation under routine practice conditions without research support. Specifically, effectiveness-implementation hybrid trials would be valuable for determining whether the fidelity levels achieved under research conditions can be maintained during independent school-led intervention delivery, which is the critical next step toward sustainable scale-up.

Conclusion

The SHIELD integrated multi-level intervention demonstrated significant and sustained effectiveness in reducing depression and internet addiction among at-risk adolescents in rural Thailand, with clinical benefits extending across multiple domains of functioning. Large effect sizes for the primary outcomes, favorable clinical response and remission rates, excellent implementation outcomes across the RE-AIM domains, and cost-effectiveness well below

conventional thresholds support the intervention's potential for up-scaling within Thailand's mental health system and possible adaptation to similar contexts. The successful integration of cultural adaptation with the evidence-based practices provides a replicable model for intervention development that respects local contexts while maintaining scientific rigor and clinical effectiveness. These findings contribute important evidence for promoting comprehensive, school-based approaches to adolescent mental health in resource-constrained settings, addressing critical gaps in the literature on the pragmatic implementation and economic viability of multi-level interventions. As Thailand and other low- and middle-income countries confront increasing rates of adolescent mental health problems amid limited specialized services, the SHIELD model presents a feasible, effective, and sustainable pathway for extending evidence-based care to underserved populations through educational systems that reach almost all adolescents. Future research extending these findings through replication, longer follow-up periods, and systematic adaptation will further refine this promising approach to addressing one of the most pressing public health challenges that contemporary youth are experiencing.

Author contributions

ST contributed substantially to the concept and design of this study, acquired the data, reviewed the literature, and analyzed and interpreted the data; drafted the manuscript; and critically edited the manuscript for important intellectual content. AS contributed substantially to data acquisition and assisted with the data collection procedures at the study sites.

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Conflicts of interest statement

The authors declare no conflicts of interest. This study was conducted without external funding. No commercial relationships or financial interests exist that could bias the research findings or manuscript content.

Data sharing statement

Individual participant data supporting the results reported in this article (text, tables, and figures) will be available to researchers for 6–24 months after article publication upon the submission of a methodologically sound proposal to the corresponding author.

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References

1. Boucher EM, Ward H, Miles CJ, Henry RD, Stoeckl SE. Effects of a digital mental health intervention on perceived stress, rumination, and loneliness in adolescents: randomized controlled trial. *J Med Internet Res* 2024;26:e54282.
2. Peake E, Miller I, Flannery J, Chen L, Lake J, Padmanabhan A. Preliminary efficacy of a digital intervention for adolescent depression: randomized clinical trial. *J Med Internet Res* 2024;26:e48467.
3. Pisani AR, Wyman PA, Cero I, Kelberman C, Gurditta K, Judd E, et al. Text messaging to extend school-based suicide prevention: pilot randomized controlled trial. *JMIR Ment Health* 2024;11:e56407.
4. Marino C, Gini G, Vieno A, Spada MM. A comprehensive meta-analysis on problematic social media use among adolescents and its associations with mental health. *JMIR Ment Health* 2023;10:e33450.
5. Chen Q, Lo CKM, Yip PSF, Chan KL. Global prevalence of cyberbullying in adolescents and its association with mental health: systematic review and meta-analysis. *Eur Child Adolesc Psychiatry* 2023;32:1107–23.
6. Walsh C, McMahon EM, Herring MP. The effects of school-based suicide prevention programs on suicidal ideation and behaviors in adolescents: systematic review and meta-analysis. *J Child Psychol Psychiatry* 2022;63:1197–207.
7. Goodkind S, Bybee D, Hess J, Newbery J, Brown K. Multilevel community-based mental health intervention for adolescents: randomized trial. *PLoS One* 2024;19:e0298369.
8. Schäfer SK, von Boros L, Schaubbruch LM, Kunzler AM, Lindner S, Koehler F, et al. Digital interventions to promote psychological resilience: a systematic review and meta-analysis. *NPJ Digit Med* 2024;7:30.
9. Yi-Frazier JP, Hilliard ME, O'Donnell MB, Zhou C, Ellisor BM, Garcia Perez S, et al. Promoting resilience in stress management for adolescents with type 1 diabetes: a randomized clinical trial. *JAMA Netw Open* 2024;7:e2428287.
10. Mei Z, Jiang W, Zhang Y, Luo S, Luo S. Mind–body therapies for resilience in adolescents: a systematic review of randomized controlled trials. *Gen Hosp Psychiatry* 2024;91:43–51.
11. Llistosella M, Ramos-Sánchez N, Conte-Berruga B, et al. A school-based multicomponent program to strengthen resilience in at-risk adolescents: randomized controlled trial. *Front Psychol* 2024;15:1478424.
12. Danpho K, Umesh P, Jones S, Chairsrichaen R, Watts P. Digital behavior and mental health among Thai adolescents in Bangkok: cross-sectional study. *BMJ Paediatr Open* 2025;9:e003238.
13. Hosiri T, Rattarittamrong R, Charoensook R, Tovar A, Sirilert P. Adverse childhood experiences, behavior problems, and resilience among adolescents in Southern Thailand. *Siriraj Med J* 2024;76:282–92.
14. Kulikov VN, Crosthwaite PC, Hall SA, Flannery JE, Strauss GS, Vierra EM, et al. A CBT-based mobile intervention as an adjunct treatment for adolescents with symptoms of depression: a virtual randomized controlled feasibility trial. *Front Digit Health* 2023;5:1062471.
15. Wani C, McCann L, Lennon M, Radu C. Digital mental health interventions for adolescents in low- and middle-income countries: systematic review. *J Med Internet Res* 2024;26:e51376.
16. Hjetland GJ, Finserås TR, Sivertsen B, Colman I, Hella RT, Andersen AIO, et al. Digital self-presentation and adolescent mental health: a longitudinal study. *BMC Public Health* 2024;24:2635.
17. Uhlhaas PJ, Torous J, Carpenter WT Jr. Digital psychiatry and youth mental health: opportunities and challenges. *Mol Psychiatry* 2023;28:1280–92.
18. Nochaiwong S, Ruengorn C, Awiphan R, Phosuya C, Ruanta Y, Kanjanarat P, et al. Transcultural adaptation and psychometric validation of the Thai Brief Resilient Coping Scale (BRCS) among general population and college students. *Sci Rep.* 2022;12:21521.
19. Organisation for Economic Co-operation and Development. OECD Digital education outlook 2021: Pushing the frontiers with artificial intelligence, blockchain and robots. Paris: OECD Publishing; 2021.
20. Sun H, Yuan C, Qian Q, He S, Luo Q. Digital resilience among individuals in school education settings: a concept analysis based on a scoping review. *Front Psychiatry* 2022;13:858515.