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Original Research Article

# Effectiveness of a Physician-Led Comprehensive School Health Promotion Programme on Health Literacy, Lifestyle Behaviours and Mental Wellbeing among School Students: A Prospective Interventional Study

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## Abstract

**Background**: Adolescents in low and middle income countries face a rising burden of unhealthy lifestyles, inadequate health literacy, and mental distress, yet physician-led comprehensive school health programmes remain unevaluated. We assessed the effectiveness of a physician-led comprehensive school health promotion programme on health literacy, lifestyle behaviours, and mental wellbeing among secondary school students in Central India.

**Methods**: We conducted a prospective pre–post interventional study in four coeducational schools (government and private) within the catchment area of a tertiary care teaching hospital. Students aged 11–18 years (n=327) completed a 12-week, 12-session programme delivered by a consistent physician team covering health literacy, nutrition, physical activity, mental health, digital health, hygiene, adolescent health, and disease prevention. The primary outcome was health literacy measured by the Health Literacy for School-Aged Children (HLSAC) instrument. Secondary outcomes included WHO-5 wellbeing index, knowledge score, self-reported physical activity, dietary habits, screen time, sleep duration, and BMI. Paired t-tests, McNemar's tests, and multivariable linear regression were used.

**Results**: Mean health literacy score increased significantly from 25.4±5.8 to 30.2±5.3 (mean difference 4.8; 95% CI 4.3–5.3; $p<0.001$), alongside gains in knowledge (4.6 points) and WHO-5 wellbeing (3.3 points). The proportion of students meeting physical activity recommendations rose from 28.1% to 42.2%, daily fruit/vegetable consumption from 11.0% to 24.2%, and screen time within limits from 34.9% to 48.9% (all $p<0.001$). Lower baseline health literacy, higher session attendance, and better baseline mental wellbeing independently predicted greater literacy gain. Overall satisfaction exceeded 94%, with 96.6% willing to recommend the programme.

**Conclusion**: A physician-led comprehensive school health promotion programme significantly improved health literacy, lifestyle behaviours, and mental wellbeing in Indian adolescents, demonstrating high acceptability and feasibility. Integrating such programmes into school health services could strengthen adolescent preventive care and advance the Health Promoting Schools agenda.

**Keywords**: Health literacy, School health promotion, Physician-led intervention, Lifestyle behaviours, Mental wellbeing



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## Introduction

Adolescence represents a critical developmental transition during which lifelong health-related behaviours are established, making it a unique window for intervention to prevent future noncommunicable diseases [1]. Globally, more than 80% of adolescents fail to meet recommended physical activity levels, while unhealthy diets, rising screen time, and inadequate sleep have become normative [2,3]. Simultaneously, mental health conditions now constitute the leading cause of disability among young people, with half of all mental disorders emerging by age 14 [4]. These behavioural and emotional challenges disproportionately affect low- and middle-income countries, where the majority of the world's adolescents reside. Because schools reach a large, captive population before risky behaviours become entrenched, they are widely recognised as one of the most effective settings for delivering health promotion interventions that can alter the trajectory of adolescent health [5].

The concept of school health promotion has evolved from narrow, disease-focused services to comprehensive, whole-school approaches. The World Health Organisation's Health Promoting Schools framework, recently updated with global standards, advocates for simultaneous action across the formal curriculum, the school's social and physical environment, and partnerships with families and communities [5]. Such multicomponent interventions are demonstrably superior to isolated, knowledge-only sessions. A Cochrane systematic review of school-based health promotion trials found that whole-school approaches significantly improved body mass index, physical activity, fruit and vegetable intake, and mental wellbeing, whereas single-component programmes produced inconsistent and often transient effects [6]. Embedding health into a school's culture and daily routines therefore holds greater promise than brief, stand-alone educational activities.

Central to adolescents' ability to adopt and sustain healthy behaviours is health literacy, defined as the cognitive and social skills that shape motivation and the ability to access, understand, and use health information [7]. Adolescent health literacy is inherently multidimensional, encompassing functional, interactive, and critical competencies. Higher levels of health literacy empower young people to make informed dietary choices, engage in regular physical activity, navigate digital health information, use preventive health services, and resist peer pressure to use substances. Conversely, inadequate health literacy is associated with risky behaviours, lower self-efficacy, and poorer long-term health outcomes. Multinational surveys consistently show that a substantial proportion of school-going adolescents have suboptimal health literacy, which limits their ability to interpret health messages and engage in self-care, particularly in the digital era, where misinformation is pervasive [3,7].

Closely intertwined with health literacy are lifestyle behaviours that track from adolescence into adulthood. Diets rich in ultra-processed foods and sugar-sweetened beverages, combined with physical inactivity, excessive screen time, and insufficient sleep, drive an epidemic of adolescent obesity [2,8]. These behaviours cluster and amplify the risk of developing hypertension, type 2 diabetes, and metabolic syndrome at increasingly younger ages. The neuroplasticity and heightened sensitivity to social rewards that characterise adolescence facilitate the formation of habits both protective and harmful, rendering this period uniquely amenable to behavioural modification. Comprehensive programmes


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that address multiple lifestyle domains concurrently are more likely to produce synergistic improvements than those targeting a single behaviour [6].

Mental wellbeing is an equally compelling public health priority that must be integrated into school health initiatives. The global prevalence of anxiety, depression, and emotional distress among adolescents has risen sharply, fuelled by academic pressure, peer victimisation, social media exposure, and socioeconomic adversity [4]. The COVID-19 pandemic has further magnified psychological distress and disrupted protective routines [3]. Poor mental health not only causes immediate suffering but also impairs academic performance, physical health, and future workforce productivity. Schools, where adolescents spend a substantial portion of their waking hours, provide an accessible, destigmatising environment for promoting emotional resilience, psychological literacy, and early identification of distress, positioning mental wellbeing as an inseparable component of any credible health promotion programme [4,6].

While teachers or health educators deliver most school health interventions, physician-led programmes confer distinct advantages that remain underexploited. Physicians bring clinical credibility, an in-depth understanding of pathophysiology and prevention, and skills in risk assessment and early disease detection. They can deliver evidence-based preventive counselling, identify students requiring clinical referral, and serve as catalysts for multidisciplinary collaboration involving teachers, school nurses, and families [5]. Physician engagement enhances the trust of parents and school authorities, builds teacher capacity through mentorship, and strengthens the continuum between school-based health promotion and primary care. Despite these theoretical benefits, prospective evaluations of physician-led, comprehensive school health promotion programmes are conspicuously scarce.

The existing literature on school health promotion is dominated by cross-sectional surveys and quasi-experimental studies that often target isolated outcomes such as nutrition or physical activity, rarely evaluating health literacy as a primary endpoint or integrating mental wellbeing in a cohesive framework [6,8]. Moreover, the evidence base is heavily skewed towards high-income settings. In India, although national policies endorse the Health Promoting School concept, rigorous intervention studies that measure multidimensional outcomes remain extremely limited, and physician-led comprehensive programmes have not been systematically evaluated in government or private school settings [8]. Without such evidence, policies and resource allocation for adolescent preventive health in low- and middle-income countries will continue to rely on extrapolation rather than context-specific data.

The present study was therefore designed to fill this critical gap by delivering a physician-led comprehensive school health promotion programme that simultaneously targets health literacy, lifestyle behaviours, and mental wellbeing. A prospective, interventional, pre-test–post-test design was employed to generate evidence that could inform school health policy, strengthen physician engagement in population health, and provide a replicable model for resource-constrained settings. Accordingly, the study aimed to evaluate the effectiveness of a physician-led comprehensive school health promotion programme on health literacy, lifestyle behaviours, and mental wellbeing among school students attending selected schools in the catchment area of a tertiary care teaching hospital in Central India.


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## Materials and Methods

### Study Design

This was a prospective, school-based, single-group interventional study employing a pre-test–post-test design. The study evaluated changes in health literacy, lifestyle behaviours, and mental wellbeing following a physician-led comprehensive school health promotion programme delivered over one academic term.

### Study Setting

The study was conducted in four coeducational government and private schools (two urban, one semi-urban, one peri-urban) situated within the defined catchment area of a 1200-bed tertiary care teaching hospital in Central India. All schools followed the national secondary education curriculum and had basic infrastructure, including a hall suitable for group sessions. The setting ensured a socioeconomically diverse sample representative of the region.

### Study Duration

The study spanned 12 months, including preparatory activities, baseline assessments, the 12-week intervention period, immediate post-intervention evaluation, and data analysis.

### Ethical Considerations

The Institutional Ethics Committee of the tertiary care teaching hospital approved the study. The study received administrative permission from the education authority and the principal of each participating school. Written informed consent was secured from a parent or legal guardian of every student, and students provided written assent before enrolment. Participation was entirely voluntary; students could withdraw at any time without academic consequence. All data were anonymised using unique identification codes and stored on password-protected institutional servers. Confidentiality was strictly maintained. Students identified during screening with signs of malnutrition, uncorrected vision or hearing deficits, untreated medical conditions, or elevated psychological distress were referred to the paediatric, adolescent medicine, or clinical psychology services of the hospital at no cost.

### Sample Size

The sample size was calculated to detect a moderate improvement in the primary outcome—health literacy—based on a standardised effect size (Cohen's d=0.3) derived from a scoping review of adolescent health literacy interventions [9]. Using a two-sided paired t-test with 80% power and $\alpha$=0.05, we required a minimum of 90 participants. Anticipating 15% attrition and allowing exploratory subgroup analyses, the target enrolment was inflated to 320 students. The final recruited sample comprised 327 students.

### Study Population

*Inclusion Criteria*: Students aged 11–18 years enrolled in grades 7–12 of participating schools, present on the day of baseline assessment, and providing parental consent and personal assent. *Exclusion Criteria*: Students with a self-reported or school-documented severe physical, cognitive, or neurodevelopmental disability precluding independent completion of the questionnaire or participation in group sessions, and those absent during the baseline data collection.

### Intervention

The intervention, entitled "HealthEdu: Physician-led Comprehensive School Health Programme", was conceived as a multicomponent, theory-informed package delivered entirely by a trained team of three physicians (two senior residents in community medicine and one attending


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paediatrician) who remained consistent throughout the study. The programme comprised 12 structured, face-to-face sessions conducted once weekly during a regular school period over one academic term. Each session lasted 60 minutes and included a 20-minute interactive lecture, a 25-minute participatory activity (demonstration, role-play, case discussion, or game), and a 15-minute question-and-answer segment. The team used audiovisual aids, anatomical models, printed posters, and pocket-sized health information cards in Hindi and English. One supervising teacher from each school attended all sessions to reinforce learning, and the programme held a single 45-minute orientation meeting with parents at the start to explain its goals and encourage home support. The sessions were organised around seven thematic modules, described below.

*Health Literacy*: Session 1 defined health literacy and its role in everyday decision-making. Sessions 2 and 3 developed skills in accessing, appraising, and applying health information from labels, social media, and clinical encounters. Critical thinking exercises addressed common myths regarding nutrition, vaccination, and alternative therapies.

*Nutrition*: Two sessions covered a balanced diet using the Indian food pyramid, identifying macronutrients, reading nutrition labels, distinguishing between whole and ultra-processed foods, and practical strategies to increase fruit and vegetable intake while limiting sugar-sweetened beverages. The session included a demonstration on preparing a healthy tiffin.

*Physical Activity*: One classroom session and one outdoor session introduced the WHO 2020 physical activity recommendations for adolescents. The outdoor component comprised age-appropriate aerobic exercises, stretching, and strength activities requiring no special equipment, with an emphasis on reducing prolonged sitting and recreational screen time.

*Mental Wellbeing*: Two sessions focused on emotional literacy, recognition of stress and anxiety, simple breathing and mindfulness techniques, and sleep hygiene. Anti-bullying messaging and peer-support strategies were reinforced through role-play. The session framed mental health as a positive state, not merely the absence of illness.

*Digital Health*: One session addressed responsible use of digital devices, setting screen-time boundaries, safeguarding sleep, recognising cyberbullying, and evaluating the credibility of online health information. The concept of "digital nutrition" was introduced to promote balanced digital consumption.

*Adolescent Health*: Two sessions provided age-appropriate, gender-sensitive education on pubertal changes, menstrual hygiene management, personal and oral hygiene, and the harms of tobacco, alcohol, and other substance use. The team promoted vaccination against human papillomavirus and tetanus-diphtheria using a non-coercive, fact-based approach.

*Preventive Health*: The final session integrated earlier themes, emphasising hand and respiratory hygiene, regular health check-ups, appropriate health-seeking behaviour, and adolescents' role as health ambassadors within their families. The team monitored fidelity using a structured session checklist; all sessions were delivered as planned.

**Outcome Measures**

*Primary Outcome*: Change in health literacy score from baseline to post-intervention,


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assessed with the Health Literacy for School-Aged Children (HLSAC) instrument [11].

*Secondary Outcomes*: Changes in (1) self-reported physical activity; (2) dietary practices (fruit, vegetable, and sugar-sweetened beverage consumption frequency); (3) recreational screen time; (4) sleep duration and quality; (5) mental wellbeing score; (6) BMI-for-age z-score; (7) health knowledge score; and (8) health-seeking behaviour (proportion reporting a health complaint for which professional care was sought).

**Study Variables**

*Sociodemographic variables*: age, sex, school type (government/private), locality (urban/semi-urban/peri-urban), parental education, and socioeconomic status assessed using the modified Kuppuswamy scale for 2023 [15].

*Anthropometric variables*: standing height was measured to the nearest 0.1 cm using a portable stadiometer, and body weight was measured to the nearest 0.1 kg using a calibrated digital scale with participants in light clothing and without shoes. Body mass index (BMI) was calculated as weight (kg)/height (m)², and BMI-for-age z-scores were derived using the WHO 2007 growth reference [14].

*Behavioural variables*: physical activity, dietary habits, screen time, sleep duration, hand hygiene, oral hygiene, and substance use.

*Mental health variable*: mental wellbeing score.

*Health literacy variable*: HLSAC total and subscale scores.

**Assessment Tools**

Health literacy was measured using the 10-item HLSAC scale (score range 10–40) which covers theoretical knowledge, practical knowledge, critical thinking, self-awareness, and citizenship [11]. The scale has demonstrated good internal consistency (Cronbach's $\alpha$=0.91) in international samples. Mental wellbeing was assessed with the WHO-5 Wellbeing Index (score range 0–25, higher scores indicating better wellbeing) [10]. Physical activity was evaluated using the Physical Activity Questionnaire for Older Children/Adolescents (PAQ-C/PAQ-A) [12], which yields a composite activity score. Dietary practices, screen time, sleep, hygiene, and health-seeking behaviour were captured using adapted, self-administered modules from the Global School-based Student Health Survey (GSHS) [13]. The full questionnaire was translated into Hindi, back-translated, culturally adapted, and pilot-tested in 30 students from a non-participating school, where it showed acceptable face validity and test-retest reliability.

**Data Collection, Data Management, Quality Assurance and Statistical Analysis**

Data were collected at two time points: baseline ($T_0$, one week before the first intervention session) and post-intervention ($T_1$, within two weeks after the final session). At each time point, trained research assistants conducted anthropometry, and participants completed the self-administered questionnaire in a supervised classroom setting. Double data entry was performed in EpiData version 4.6, with discrepancies resolved against the original forms. All analyses were carried out using IBM SPSS Statistics version 29.0. We examined the normality of continuous variables using the Shapiro-Wilk test and visual inspection of Q-Q plots. Paired differences in primary and secondary outcomes were analysed using the paired t-test for normally distributed variables and the Wilcoxon signed-rank test otherwise. We applied McNemar's test to paired categorical outcomes. Multivariable linear regression was used to identify


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sociodemographic predictors of change in health literacy score, with adjustment for potential confounders. All tests were two-sided, and $p < 0.05$ was considered statistically significant.

## Results

A total of 327 students (mean age 14.2 ± 1.8 years, 53.5% female) were enrolled and completed both baseline and post-intervention assessments; no participant was lost to follow-up.

**Table 1. Baseline Characteristics of Study Participants (N=327)**

| Characteristic | Value |
|---|---|
| Age (years), mean ± SD | 14.2 ± 1.8 |
| **Sex, n (%)** | |
| Male | 152 (46.5) |
| Female | 175 (53.5) |
| **School type, n (%)** | |
| Government | 189 (57.8) |
| Private | 138 (42.2) |
| **Residence, n (%)** | |
| Urban | 112 (34.3) |
| Semi-urban | 128 (39.1) |
| Peri-urban | 87 (26.6) |
| **BMI category†, n (%)** | |
| Underweight | 59 (18.0) |
| Normal weight | 210 (64.2) |
| Overweight | 39 (11.9) |
| Obesity | 19 (5.8) |

†BMI-for-age z-scores classified according to WHO 2007 growth reference.
BMI, body mass index; SD, standard deviation.

Table 1 summarises baseline characteristics of the 327 participants. The sample comprised students from government and private schools, with representation from urban, semi-urban, and peri-urban localities. The majority had a normal BMI, although approximately one-fifth were underweight and 17.7% had overweight or obesity, reflecting the double burden of malnutrition typical of this setting.

**Table 2. Comparison of Health Literacy, Knowledge Score and Mental Wellbeing Before and After Intervention (N=327)**

| Outcome | Pre-intervention Mean ± SD | Post-intervention Mean ± SD | Mean Difference (95% CI) | t | p value |
|---|---|---|---|---|---|
| Health literacy (HLSAC) | 25.4 ± 5.8 | 30.2 ± 5.3 | 4.8 (4.3 to 5.3) | 18.3 | <0.001 |
| Knowledge score | 11.2 ± 3.2 | 15.8 ± 2.9 | 4.6 (4.2 to 5.0) | 22.5 | <0.001 |
| WHO-5 wellbeing index | 14.5 ± 4.6 | 17.8 ± 4.3 | 3.3 (2.9 to 3.7) | 16.1 | <0.001 |

Following the intervention, all three core outcomes improved significantly. Mean health literacy score increased by 4.8 points (95% CI 4.3 to 5.3; $p<0.001$), reflecting a large effect. The knowledge score improved by 4.6 points (95% CI 4.2 to 5.0; $p<0.001$), and the WHO-5 wellbeing index rose by 3.3 points (95% CI 2.9 to 3.7; $p<0.001$). These results indicate robust programme effectiveness across educational and psychosocial domains.


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**Table 3. Changes in Lifestyle Behaviours Before and After Intervention (N=327)**

| Behaviour | Pre-intervention (%) | Post-intervention (%) | Absolute improvement (percentage points) | p value * |
|---|---|---|---|---|
| Adequate physical activity † | 92 (28.1) | 138 (42.2) | 14.1 | <0.001 |
| Daily breakfast consumption | 180 (55.0) | 236 (72.2) | 17.2 | <0.001 |
| ≥5 servings fruit/vegetables per day | 36 (11.0) | 79 (24.2) | 13.2 | <0.001 |
| Recreational screen time ≤2 h/day | 114 (34.9) | 160 (48.9) | 14.0 | <0.001 |
| Adequate sleep duration‡ | 170 (52.0) | 216 (66.1) | 14.1 | <0.001 |
| *McNemar test. †≥60 minutes of moderate-to-vigorous physical activity daily. ‡8–10 hours per night for ages 13–18 years. | | | | |

Self-reported lifestyle behaviours improved consistently and significantly post-intervention. The proportion of students meeting physical activity recommendations increased by 14.1 percentage points, while daily breakfast consumption rose by 17.2 percentage points. Similarly, adequate fruit and vegetable intake more than doubled. Screen time within recommended limits improved by 14.0 percentage points, and sufficient sleep duration increased by 14.1 percentage points ($p<0.001$ for each).

**Table 4. Multivariable Linear Regression Analysis of Predictors of Improvement in Health Literacy Score (N=327)**

| Predictor | β | 95% CI | p value |
|---|---|---|---|
| Age (years) | −0.12 | −0.30 to 0.06 | 0.19 |
| Female sex (vs. male) | 0.15 | −0.42 to 0.72 | 0.61 |
| Private school (vs. government) | 0.58 | −0.05 to 1.21 | 0.07 |
| Baseline health literacy score | −0.48 | −0.57 to −0.39 | <0.001 |
| Baseline WHO-5 score | 0.11 | 0.03 to 0.19 | 0.007 |
| Sessions attended (0–12) | 0.22 | 0.08 to 0.36 | 0.002 |
| Dependent variable: change in HLSAC score (post − pre). Adjusted $R^2 = 0.31$. β, unstandardised regression coefficient; CI, confidence interval. | | | |

In the adjusted regression model, baseline health literacy was inversely associated with improvement, indicating that students with lower initial scores gained the most ($\beta = -0.48$; 95% CI −0.57 to −0.39; $p < 0.001$).


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Higher baseline mental wellbeing and greater session attendance were positively associated with improvement. Age, sex, and school type did not significantly predict change in health literacy after adjustment. The model explained 31% of the variance.

**Table 5. Participant Satisfaction with the Physician-Led School Health Promotion Programme (N=327)**

| Aspect | Very satisfied n (%) | Satisfied n (%) | Neutral n (%) | Dissatisfied n (%) |
|---|---|---|---|---|
| Overall satisfaction | 223 (68.2) | 85 (26.0) | 14 (4.3) | 5 (1.5) |
| Relevance of sessions | 210 (64.2) | 95 (29.1) | 16 (4.9) | 6 (1.8) |
| Clarity of teaching | 231 (70.6) | 79 (24.2) | 12 (3.7) | 5 (1.5) |
| Physician interaction | 242 (74.0) | 72 (22.0) | 10 (3.1) | 3 (0.9) |
| Practical usefulness | 218 (66.7) | 88 (26.9) | 15 (4.6) | 6 (1.8) |
| Willingness to recommend* | 259 (79.2) | 57 (17.4) | 9 (2.8) | 2 (0.6) |
| *Proportion willing to recommend the programme to peers. | | | | |

Table 5 presents participant satisfaction ratings. The vast majority of students expressed high levels of satisfaction with the programme: 94.2% were very satisfied or satisfied overall, and 96.6% indicated willingness to recommend it to peers. Most participants rated the sessions as relevant, clear, and practically useful. Physician interaction received the highest endorsement, with 96.0% reporting satisfaction, corroborating the acceptability of the physician-led delivery model.

## Discussion

This prospective interventional study demonstrates that a physician-led comprehensive school health promotion programme, delivered over one academic term in Central India, yielded significant improvements in health literacy, health knowledge, mental wellbeing, and multiple lifestyle behaviours among school students aged 11–18 years. The uniformly high participant satisfaction and complete retention further underscore the acceptability and feasibility of this delivery model. Taken together, these findings provide robust evidence that a structured, multi-domain, clinician-facilitated programme can meaningfully advance several dimensions of adolescent health simultaneously.

The substantial improvement in health literacy, measured using the validated HLSAC instrument [11], represents a central achievement. Health literacy in adolescence is a critical determinant of lifelong health behaviours and effective navigation of healthcare systems [7]. The 4.8-point gain observed is clinically meaningful and surpasses the effect sizes reported in many school-based health literacy interventions, which have often been fragmented or limited to knowledge transmission [9]. We attribute this robust response to the programme's emphasis on functional, interactive, and critical health literacy through repeated, interactive sessions that moved beyond passive information delivery. The physician's credibility, coupled with contextually relevant examples and hands-on activities, likely enhanced students' motivation to access, appraise, and apply health information. Enhancing health


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literacy during the formative school years equips young people to resist misinformation, make informed dietary and physical activity choices, and engage in preventive care, thereby addressing a fundamental social determinant of health [7].

The parallel rise in knowledge scores reinforces the intervention's educational value. While knowledge alone does not guarantee behaviour change, it is a necessary precursor for informed decision-making [18]. The interactive pedagogical methods—role plays, group discussions, and demonstrations—may have promoted deeper cognitive processing and retention compared with didactic instruction. This finding aligns with evidence from systematic overviews indicating that school-based health interventions in low- and middle-income countries can effectively increase health knowledge, particularly when they employ participatory techniques [18].

A particularly encouraging outcome was improved mental wellbeing, as captured by the WHO-5 index. The rising global burden of adolescent depression, anxiety, and emotional distress, compounded by academic pressure, social media exposure, and pandemic-related disruptions, demands that school health programmes integrate psychosocial components [4]. The present programme's inclusion of stress management, mindfulness techniques, sleep hygiene, and anti-bullying messaging, delivered in a destigmatising classroom environment, likely contributed to the 3.3-point increase in wellbeing. This finding is consistent with meta-analytic evidence that school-based social and emotional learning programmes produce significant improvements in emotional wellbeing and resilience [17]. Integrating mental health into a broader health promotion framework, rather than delivering it in isolation, may reduce stigma and enhance uptake.

The programme also catalysed statistically significant, population-level shifts across a range of lifestyle behaviours: physical activity, daily breakfast consumption, fruit and vegetable intake, recreational screen time, and sleep duration. Achieving simultaneous improvements in multiple behaviours is methodologically challenging yet essential, as these behaviours cluster and mutually reinforce one another [1,2]. For example, reduced screen time may directly facilitate longer sleep and provide opportunities for physical activity. The magnitude of change observed—proportions meeting recommendations increasing by 13–17 percentage points—compares favourably with multicomponent school-based interventions reviewed in the Cochrane synthesis by Langford et al. [6], where whole-school approaches improved physical activity and dietary behaviours. The programme's comprehensive design, targeting multiple risk domains concurrently, likely generated a synergistic effect that enabled habit formation during a neurodevelopmentally sensitive window [21]. Practical demonstrations, such as healthy tiffin preparation and equipment-free exercise routines, may have lowered perceived barriers to behaviour adoption in a resource-constrained setting.

The regression analysis showed that students with lower baseline health literacy benefited most, a finding with equity implications: the programme may have narrowed the health literacy gap among disadvantaged learners. Higher attendance was independently associated with greater improvement, underscoring the importance of session fidelity and consistent engagement. Interestingly, baseline mental wellbeing positively predicted literacy gain, suggesting that emotional readiness facilitates learning. These observations can


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inform future interventions by prioritising students with low health literacy and investing in strategies to maximise attendance and psychological support.

Participant satisfaction was exceptionally high, with over 94% of students expressing overall satisfaction and 96% willing to recommend the programme. Physician interaction garnered the most favourable rating, reflecting the trust and authority that clinicians bring to the school setting. High acceptability is a critical implementation outcome that predicts intervention adoption, fidelity, and sustainability. It also indicates that the model is not only effective but also congruent with students' expectations and needs.

From a policy perspective, these results are immediately relevant. India's Ayushman Bharat School Health and Wellness Programme aims to provide health promotion at government schools through trained health ambassadors, yet physician-led elements remain sparse [20]. Embedding a structured, physician-delivered module within the existing school health infrastructure could strengthen the preventive care continuum, connecting schools with nearby tertiary hospitals. This model aligns with the WHO global standards for Health Promoting Schools, which advocate for partnerships between the health and education sectors [5], and contributes directly to Sustainable Development Goal 3 (Good Health and Wellbeing) and Goal 4 (Quality Education).

The study has several strengths. The prospective interventional design with high retention minimised attrition bias. The use of internationally validated instruments like HLSAC, WHO-5, PAQ-C/A, and GSHS modules—enhances measurement validity and comparability. The comprehensive, multi-domain intervention, delivered entirely by physicians, reflects a replicable, real-world model. Including both government and private schools across urban, semi-urban, and peri-urban settings improves the generalisability of findings within the regional context.

Nevertheless, important limitations remain. The single-group pre-test–post-test design, without a control arm, cannot rule out secular trends or maturation effects. Although the short time frame makes large secular changes unlikely, future studies should employ cluster-randomised controlled designs. Behavioural outcomes were self-reported, carrying the risk of social desirability bias. The absence of a longer-term follow-up precludes assessment of sustainability. The study was confined to one hospital catchment area, limiting geographical generalisability. Despite these caveats, the internal consistency of improvements across objective and subjective measures strengthens confidence in the intervention's true effect.

Future research should evaluate this model through multicentre cluster-randomised controlled trials with extended follow-up, incorporate objective activity monitors and dietary biomarkers, assess cost-effectiveness, and explore digital platforms to reinforce messaging. Implementation science studies are needed to examine fidelity, scalability, and integration into the national school health programme.

## Conclusion

This study provides compelling evidence that a physician-led comprehensive school health promotion programme can significantly improve health literacy, knowledge, mental wellbeing, and multiple lifestyle behaviours among adolescents in Central India. The model capitalises on physicians' clinical credibility and pedagogical authority to deliver an engaging, multicomponent intervention within the familiar school environment. The


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high acceptability and equitable benefits—particularly for those with lower baseline health literacy—highlight its potential as a scalable public health strategy. However, the single-group pre–post design, absence of a control group, reliance on self-reported behavioural measures, short follow-up period, and limited geographical setting restrict causal inference and generalisability**.** Integrating such programmes into existing school health frameworks could strengthen adolescent preventive care, reduce the future burden of noncommunicable diseases, and contribute to the global agenda of Health Promoting Schools. While the single-group design warrants cautious interpretation, the findings provide a solid foundation for larger, controlled trials and policy dialogue aimed at embedding physician-led health promotion in routine school health services.

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