RESEARCH ARTICLE

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Health Literacy and Factors Associated with HPV Vaccination among Adolescent Students: A Cross-Sectional Analytic Study

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Abstract

Background: Human papillomavirus (HPV) vaccination is a key strategy for cervical cancer prevention. Health literacy may influence vaccine uptake, but evidence among adolescents remains limited in Thailand. This study aimed to examine the association between health literacy, social support, and HPV vaccination among female secondary school students. **Materials and Methods:** A cross-sectional analytical study was conducted between November 2024 and January 2025 in Chalerm Phrakiat District, Nakhon Si Thammarat Province, Thailand. A total of 296 female students aged 13–18 years were included, comprising 148 unvaccinated participants and 148 vaccinated controls. Data were collected using a validated questionnaire covering demographic characteristics, health literacy (six subscales), and perceived social support and role modeling (two subscales). Logistic regression analyses were performed to identify factors associated with HPV vaccination. **Results:** Approximately one-third of both groups had fair overall health literacy (33.11% and 37.84%, respectively). Participants in senior high school were significantly less likely to be vaccinated (AOR = 2.27, 95% CI: 1.37–3.76). Interestingly, participants with low knowledge and understanding were more likely to be vaccinated (AOR = 0.34, 95% CI: 0.16–0.69), while those with low communication skills were more likely to be unvaccinated (AOR = 1.91, 95% CI: 1.05–3.48). Overall health literacy was not significantly associated with vaccination status. **Conclusion:** Specific dimensions of health literacy, particularly knowledge and communication skills, were significantly associated with HPV vaccination. These findings highlight the need for targeted health education interventions focusing on improving communication and reinforcing key knowledge to increase vaccine uptake among adolescents.

Keywords: Health communication- Behavioral determinants- Vaccination acceptance- Youth health promotion

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Introduction

Cervical cancer is a malignant tumor that arises in the cells of the cervix, the lower part of the uterus that connects to the vagina. It typically begins in the transformation zone of the cervix, an area where glandular and squamous cells meet and are prone to abnormal changes [1]. These changes, known as cervical dysplasia, can develop into cancer over time if left untreated. The primary cause of cervical cancer is persistent infection with high-risk types of the Human Papillomavirus (HPV), a common virus transmitted through sexual contact [2, 3]. While most HPV infections resolve spontaneously, persistent infection with oncogenic HPV types, particularly HPV-16 and HPV-18, can lead to cellular mutations and cancer progression [4, 5]. Cervical cancer generally develops slowly over many years, allowing opportunities for early detection and prevention. It can affect women at any age, though it is most commonly diagnosed in midlife. As a preventable disease, cervical cancer can be effectively controlled through vaccination, regular screening, and appropriate treatment [6].

Globally, cervical cancer is the fourth most common cancer in women, with an estimated 660,000 new cases and approximately 350,000 deaths reported in 2022 [7]. The burden of disease is highest in low- and middle-income countries [8], where about 85% of cases and deaths occur due to limited access to screening and treatment services [9]. In Asia, cervical cancer remains a significant health concern, particularly in Southeast Asia [10], where incidence and mortality rates are among the highest in the region [11]. In Thailand, cervical cancer is the second most common cancer among women, following breast cancer, with an age-standardized incidence rate (ASR) of 16.4 per 100,000 women and an age-standardized mortality rate (ASMR) of 7.4 per 100,000 women [12]. Data from the

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southern region of Thailand indicate lower HPV vaccine coverage and continued reports of cervical cancer cases, highlighting regional disparities in prevention efforts [12].

The Human Papillomavirus (HPV) vaccine is one of the most effective tools for preventing cervical cancer [13]. It targets the high-risk HPV strains most commonly associated with the development of cervical cancer, particularly HPV-16 and HPV-18 [14]. There are three main types of HPV vaccines: bivalent, quadrivalent, and nonavalent, each offering protection against various HPV strains [15]. The World Health Organization recommends that female adolescents aged 9–14 receive the vaccine prior to becoming sexually active to ensure optimal effectiveness [16]. Clinical studies have shown that HPV vaccination significantly reduces the incidence of cervical precancers and infections caused by vaccine-related HPV types [17, 18]. Countries that have implemented national HPV vaccination programs have reported substantial declines in HPV prevalence and cervical abnormalities [19].

Despite the availability of the HPV vaccine, coverage remains suboptimal in certain areas, particularly in rural regions like Chaloem Phra Kiat District in southern Thailand. This district is geographically characterized by lowland terrain and canal networks, which limit accessibility to health services, including school-based vaccination programs. Research specifically examining the influence of health literacy on HPV vaccine uptake in these settings is limited. Previous studies have mostly focused on general awareness or attitudes, often neglecting to analyze how different dimensions of health literacy—such as communication skills or decision-making—affect vaccine behavior [20-22]. Moreover, regional and cultural factors influencing health-seeking behavior are often underexplored. This study aims to assess health literacy levels among adolescent girls who have and have not received the first dose of the HPV vaccine and to identify associated factors. Findings from this study can inform more targeted public health strategies and school-based health education, particularly in underserved and geographically challenging regions. The results may also contribute to national efforts in improving HPV vaccine coverage and reducing cervical cancer incidence.

Materials and Methods

Study Design

This cross-sectional analytical study was conducted between November 2024 and January 2025. The study took place in Chalerm Phrakiat District, Nakhon Si Thammarat Province, located in south-central Thailand. The setting included two large high schools under the jurisdiction of Chalerm Phrakiat Hospital in Chalerm Phrakiat District, Nakhon Si Thammarat Province.

Population and Sample

The study population consisted of female secondary school students aged 13–18 years from two high schools under the supervision of Chalerm Phrakiat Hospital in Chalerm Phrakiat District. The total population included 948 students. The sample was divided into two groups: cases and controls. Cases were defined as female adolescents who had not received the HPV vaccine, while controls were those who had received the HPV vaccine.

The sample size was calculated based on a cross-sectional analytical study design using the Fleiss method [23, 24]. The significance level was set at 0.05 ($Z\alpha/2 = 1.96$) and power at 0.80 ($Z1-\beta = 0.99$), with a case-to-control ratio of 1:1. The estimated probability of HPV vaccination among participants with poor and high knowledge of HPV infection and vaccination was 0.02 and 0.15, respectively. The minimum required sample size was 72 participants per group. To account for design effects due to different school settings (design effect = 2), the sample size was increased to 144 per group.

During the study period, 148 unvaccinated participants were identified, and all were included as cases. Controls were selected using systematic sampling, matched by school and class. In total, 148 cases and 148 controls were included in the study.

Variable

Prior to data collection, the researchers validated the questionnaire by piloting it with a group of participants from another school with similar characteristics. Data collection was approved by the Human Research Ethics Committee of Thaksin University and permitted by the principals of the two participating schools. Researchers administered a structured questionnaire divided into three sections: (1) demographic characteristics, (2) health literacy on cervical cancer and HPV vaccination, and (3) social support.

The demographic characteristics consisted of 11 checklist items, including age, religion, current education level, body mass index (BMI in kg/m^2), underlying health conditions, history of sexual intercourse, condom use during intercourse, smoking, and alcohol consumption. The health literacy included 24 items across six subscales: health and service accessibility (4 items), knowledge and understanding (4 items), communication skills (4 items), self-management (4 items), decision-making skills (4 items), and media literacy (4 items). Responses were rated on a five-point Likert scale (1 = lowest to 5 = highest) [20-22]. The perceived social support and health role modeling comprised 15 items across two subscales: perceived social support (6 items) and health role models (9 items), also rated on a five-point Likert scale (1 = lowest to 5 = highest) [25]. Health literacy scores were interpreted into four categories: poor (<72 points or <60%), fair (72–83.99 points or 60–<70%), good (84–95.99 points or 70–<80%), and excellent (96–120 points or ≥80%). Perceived social support and health role modeling scores were classified into three categories: poor (<51 points or <60%), moderate (51–67.79 points or 60–<80%), and high (≥68 points or ≥80%).

The questionnaires were validated by three experts—a family medicine physician, a nurse practitioner, and a public health methodologist. Content validity, assessed using the Index of Item-Objective Congruence (IOC), ranged from 0.66 to 1.00. The questionnaires were revised based on expert feedback and piloted in a similar setting in another district of Nakhon Si Thammarat Province.

Cronbach's alpha coefficients for the health literacy and social support sections were 0.89 and 0.82, respectively, indicating good internal consistency.

Statistical Methods

Data analysis consisted of both descriptive and inferential statistics. Descriptive statistics were used to describe participants' demographic characteristics, health literacy related to cervical cancer, and perceived social support and health role modeling levels.

The primary research objective was to identify factors associated with HPV vaccination. The outcome variable HPV vaccination status was treated as a dichotomous variable: unvaccinated (coded as 1) and vaccinated (coded as 0). Bivariate analysis was performed using simple logistic regression to examine associations between HPV vaccination status and independent variables, including demographic factors, health literacy, and perceived social support and health role modeling.

For bivariate analysis, health literacy (both overall and subscales) and social support were also categorized based on cutoff scores. Health literacy was divided into high (≥70%) and low (<70%), while perceived social support and health role modeling was categorized as high (≥60%) and low (<60%). Continuous variable analysis was also performed for overall and subscale scores of health literacy and perceived social support and health role modeling. Multivariate analysis included both categorical and continuous forms of overall health literacy, with sensitivity analysis adjusted for all potential confounding variables. A separate multivariate model was constructed to examine associations between HPV vaccination and individual health literacy subscales.

The multivariable model included all variables with a p-value ≤ 0.25 from the bivariate analysis, encompassing both demographic and health literacy factors. Separate models were constructed for overall health literacy (both categorical and continuous forms) and for subscale analysis to minimize multicollinearity and enhance interpretability. Variables meeting the inclusion threshold were entered into the multivariate logistic regression using a backward elimination approach to identify independent predictors of HPV vaccination. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test. Results were reported as odds ratios (OR) and adjusted odds ratios (AOR) with 95% confidence intervals (95% CI). An OR greater than 1 indicated a lower likelihood of having received the HPV vaccine (i.e., more likely to be unvaccinated), an OR less than 1 indicated a higher likelihood of vaccination, and an OR equal to 1 indicated no association between the variable and vaccination status.

Ethical Considerations

This study was approved by the Human Research Ethics Committee of Thaksin University (COA No. TSU 2024_336, REC No. 0781) on December 10, 2024. The research was conducted in accordance with ethical guidelines, ensuring participant anonymity and the protection of all personal information. No identifiable data were collected or disclosed. Furthermore, the study was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki and the Belmont Report, which emphasize respect for persons, beneficence, and justice in research involving human subjects.

Results

Demographic Characteristics

Among the case and control groups, over half of the unvaccinated participants (56.08%) and approximately one-third of the vaccinated participants (35.14%) were aged 16–18 years, with mean ages of 15.97 years (SD = 1.66) and 14.74 years (SD = 2.03), respectively. Nearly all participants were Buddhist (100.00% in the unvaccinated group vs. 99.32% in the vaccinated group). More than half of the unvaccinated group (56.08%) and about one-third of the vaccinated group (35.14%) were enrolled in senior high school.

The majority of participants in both groups had a normal body weight (81.76% in the unvaccinated group vs. 76.35% in the vaccinated group), with average BMIs of 19.83 (SD = 3.72) and 20.60 (SD = 4.40) kg/m², respectively.

Regarding underlying health conditions, 5.41% of the unvaccinated group and 12.84% of the vaccinated group reported having a medical history, including allergies (4.05% vs. 5.41%) and anemia (1.35% vs. 2.70%). Approximately the same proportion of participants (12.16%) in both groups reported having had sexual intercourse, and similar rates were observed for consistent condom use during intercourse (9.46% vs. 8.78%). Additionally, 7.43% of the unvaccinated group and 5.41% of the vaccinated group had a history of smoking, while 19.00% and 23.65%, respectively, reported alcohol consumption.

Health Literacy and Social Support

In both the case and control groups, approximately one-third of participants demonstrated fair overall health literacy (33.11% vs. 37.84%). Regarding health literacy subscales, around half of the participants showed excellent access to health information and services (50.00% vs. 43.24%). Among the unvaccinated group, 72.30% had excellent knowledge and understanding, compared to one-third in the vaccinated group.

Approximately one-third of participants in both groups had low communication skills (38.51% vs. 33.11%). About half had low self-management abilities (51.35% vs. 56.08%). While 35.14% of the unvaccinated group had excellent decision-making skills, nearly half of the vaccinated group (40.54%) demonstrated low decision-making ability. Additionally, one-third of participants showed excellent media literacy (44.59% vs. 35.14%), as shown in Table 1.

Regarding perceived social support and health role modeling, nearly half of the participants in both groups reported fair levels (45.95% vs. 52.70%). For the perceived social support subscale, about half had excellent support (45.95% vs. 58.78%). The majority of participants in both groups (91.22%) reported having strong positive health role models in health, as shown in Table 2.

Table 2. Overall and Subscale of Social Support among Participants (n = 296)

Overall and subscale of social support	n (%) of Cases (n = 148)			Mean (SD)	n (%) of Controls (n = 148)			Mean (SD)
	Poor	Moderate	High		Poor	Moderate	High	
Health role models	29 (19.59)	51 (34.46)	68 (45.95)	2.26 (0.77)	24 (16.22)	37 (25.00)	87 (58.78)	2.42 (0.76)
Perceived social support	4 (2.70)	9 (6.08)	135 (91.22)	2.89 (0.34)	3 (2.03)	10 (6.76)	135 (91.22)	2.89 (0.37)
Overall social support	59 (39.86)	68 (45.95)	21 (14.19)	54.69 (10.13)	48 (32.43)	78 (52.70)	22 (14.86)	56.81 (10.48)

Table 1. Overall and Subscale of Health Literacy on Cervical Cancer Screening and HPV Vaccine among Participants (n = 296)

Overall and Subscale of Health Literacy	n (%) of Cases (n = 148)				Mean (SD)	n (%) of Controls (n = 148)				Mean (SD)
	Poor	Fair	Good	Excellent		Poor	Fair	Good	Excellent	
Health and services accessibility	22 (14.86)	7 (4.73)	45 (30.41)	74 (50.00)	3.15 (1.06)	26 (17.57)	23 (15.54)	35 (23.65)	64 (43.24)	2.92 (1.13)
Knowledge and understanding	10 (6.76)	7 (4.73)	24 (16.22)	107 (72.30)	3.54 (0.86)	27 (18.24)	18 (12.16)	35 (23.65)	68 (45.95)	2.97 (1.14)
Communication skills	57 (38.51)	24 (16.22)	28 (18.92)	39 (26.35)	2.33 (1.23)	49 (33.11)	27 (18.24)	37 (25.00)	35 (23.65)	2.39 (1.17)
Self-management	76 (51.35)	14 (9.46)	27 (18.24)	31 (20.95)	2.08 (1.23)	83 (56.08)	11 (7.43)	29 (19.59)	25 (16.89)	1.97 (1.20)
Decision making skills	41 (27.70)	16 (10.81)	39 (26.35)	52 (35.14)	2.68 (1.21)	60 (40.54)	18 (12.16)	32 (21.62)	38 (25.68)	2.32 (1.24)
Media literacy	35 (23.65)	13 (8.78)	34 (22.97)	66 (44.59)	2.88 (1.21)	50 (33.78)	18 (12.16)	28 (18.92)	52 (35.14)	2.55 (1.27)
Overall health literacy	14 (9.46)	49 (33.11)	41 (27.70)	44 (29.73)	87.61 (13.87)	21 (14.19)	56 (37.84)	39 (26.35)	32 (21.62)	84.62 (14.18)

Bivariate Analysis

Crude logistic regression analysis revealed that age, education level, and the presence of underlying health conditions were significantly associated with HPV vaccination among participants. Participants aged 16–18 years were 2.35 times more likely not to be vaccinated against HPV compared to younger participants (OR = 2.35, 95% CI: 1.47–3.76). Similarly, those enrolled in senior high school were also 2.35 times more likely to be unvaccinated than those in junior high school (OR = 2.35, 95% CI: 1.47–3.76). In contrast, participants with underlying health conditions were 62% more likely to be vaccinated compared to those without such conditions (OR = 0.38, 95% CI: 0.16–0.91), indicating a protective association.

Other factors such as BMI (p-value = 0.445), history of sexual intercourse (p-value = 1.000), smoking (p-value = 0.479), and alcohol consumption (p-value = 0.321) were not significantly associated with HPV vaccination status, as shown in Table 3.

Crude logistic regression analysis showed that overall health literacy related to cervical cancer was not significantly associated with HPV vaccination status (OR = 0.68, 95% CI: 0.43–1.08). However, certain health literacy subscales were significantly associated with vaccination, including health and service accessibility, knowledge and understanding, and decision-making skills.

Participants with low access to health services were 51% more likely to be vaccinated against HPV (OR = 0.49, 95% CI: 0.29–0.83). Similarly, those with low knowledge and understanding were 71% more likely to be vaccinated (OR = 0.29, 95% CI: 0.16–0.54), and those with poor decision-making skills were 44% more likely to be vaccinated (OR = 0.56, 95% CI: 0.35–0.89).

Regarding perceived social support and health role modeling, participants with low overall perceived social support and health role modeling were not significantly associated with HPV vaccination (OR = 0.94, 95% CI: 0.49–1.80). However, participants with low perceived social support at the subscale level were 41% more likely to be vaccinated (OR = 0.59, 95% CI: 0.37–0.94), as shown in Table 4.

Additionally, crude analysis of continuous variables related to overall and subscale health literacy and perceived social support and health role modeling was performed (Table 5). The results showed that for each one-point increase in the knowledge and understanding score, participants were 1.19 times less likely to be vaccinated (OR = 1.19, 95% CI: 1.09–1.30).

Multivariate Logistic Regression

A logistic regression model was constructed to identify factors independently associated with HPV vaccination. The analysis revealed that education level was significantly associated with vaccination status. Participants enrolled in senior high school were 2.27 times more likely to be unvaccinated compared to those in

Table 3. Crude Analysis of Demographic Factors associated with HPV Vaccination among Participants (n = 296)

Factors	Case (n = 148)		Controls (n = 148)		OR	95%CI	p-value
	n	%	n	%			
Age (year)							<0.001
13-15	65	40.37	96	59.63	ref.		
16-18	83	61.48	52	38.52	2.35	1.47-3.76	
Education							<0.001
Junior high school	65	40.37	96	59.63	ref.		
Senior high school	83	61.48	52	38.52	2.35	1.47-3.76	
Body mass index (kg/m^2)							0.445
Normal weight (≤22.99)	121	51.71	113	48.29	ref.		
Overweight (23.00-24.99)	12	48	13	52	0.86	0.37-1.96	
Obesity (≥25.00)	15	40.54	22	59.46	0.63	0.31-1.28	
Underlying health conditions							0.031
No	140	52.04	129	47.96	ref.		
Yes	8	29.63	19	70.37	0.38	0.16-0.91	
History of sexual intercourse							1.00
No	130	50	130	50	ref.		
Yes	18	50	18	50	1.00	0.49-2.00	
Smoking							0.479
No	137	49.46	140	50.54	ref.		
Yes / ex-smoker	11	57.89	8	42.11	1.40	0.54-3.60	
Alcohol drinking							0.321
No	120	51.5	113	48.5	ref.		
Yes / ex-drinker	28	44.44	35	66.67	1.33	0.76-2.32	

Note: OR, Odds ratios; 95%CI, 95 Percent confidence interval

Table 4. Crude Analysis of Categorical Outcome of Health Literacy on Cervical Cancer Screening and HPV Vaccine and Perceived Social Support and Health Role modeling factors associated with HPV vaccination among participants (n = 296)

Factors	Case (n = 148)		Controls (n = 148)		OR	95%CI	p-value
	n	%	n	%			
Overall health literacy related to cervical cancer and HPV vaccination							0.104
High	85	54.49	71	45.51	ref		
Low	63	45	77	55.00	0.68	0.43-1.08	
Health and services accessibility							0.009
High	119	54.59	99	45.41	ref		
Low	29	37.18	49	62.82	0.49	0.29-0.83	
Knowledge and understanding							<0.001
High	131	55.98	103	44.02	ref		
Low	17	27.24	45	72.76	0.29	0.16-0.54	
Communication skills							0.560
High	67	48.28	72	51.8	ref		
Low	81	51.59	76	48.41	1.14	0.72-1.80	
Self-management							0.632
High	58	51.79	54	48.21	ref		
Low	90	48.91	94	51.09	0.89	0.55-1.42	
Decision making skills							0.015
High	91	56.52	70	43.48	ref		
Low	57	42.22	78	57.78	0.56	0.35-0.89	
Media literacy							0.180
High	100	55.56	80	44.44	ref		
Low	48	41.38	68	58.62	0.56	0.35-0.90	
Overall perceive social support and health role modeling							0.869
High	21	48.84	22	51.56	ref		
Low	127	50.2	126	49.80	0.94	0.49-1.80	
Perceived social support							0.027
High	68	43.87	87	56.13	ref		
Low	80	56.74	61	43.26	0.59	0.37-0.94	
Health role models							1.000
High	135	50	135	50.00	ref		
Low	13	50	13	500	1.00	0.44-2.23	

Note: OR, Odds ratios; 95%CI, 95 Percent confidence interval

Table 5. Crude Analysis of Continuous Variable of Health Literacy on Cervical Cancer Screening and HPV Vaccine and Perceived Social Support and Health Role Modeling Factors associated with HPV Vaccination among Participants (n = 296)

Factors	OR	95%CI	p-value
Overall health literacy	1.01	0.99-1.03	0.068
Health and services accessibility	1.06	0.97-1.15	0.180
Knowledge and understanding	1.19	1.09-1.30	<0.001
Communication skills	0.98	0.90-1.06	0.650
Self-management	1.02	0.95-1.09	0.567
Decision making skills	1.06	0.98-1.15	0.111
Media literacy	1.08	0.99-1.17	0.053
Overall social support	1.02	0.99-1.04	0.079
Perceived social support	1.04	0.99-1.09	0.118
Health role models	1.02	0.99-1.06	0.099

Note: OR, Odds ratios; 95%CI, 95 Percent confidence interval

junior high school (AOR = 2.27, 95% CI: 1.37–3.76). The multivariate model was adjusted for potential confounding variables, including underlying diseases, smoking, alcohol consumption, and overall health literacy, as shown in Supplementary Table 1.

Furthermore, a multivariate analysis was performed on health literacy variables in both categorical and continuous forms. The findings indicated that overall health literacy was not significantly associated with HPV vaccination in either form categorical (AOR = 0.92, 95% CI: 0.55–1.53) or continuous (AOR = 1.00, 95% CI: 0.89–1.02), as presented in Supplementary Table 2.

However, when analyzing specific health literacy subscales, significant associations were found. Participants with low knowledge and understanding were 66% more likely to be vaccinated than those with high levels of knowledge (AOR = 0.34, 95% CI: 0.16–0.69). In contrast, participants with low communication skills were 1.91 times more likely to be unvaccinated compared to those with high communication skills (AOR = 1.91, 95% CI: 1.05–3.48). These results were adjusted for education, alcohol consumption, and underlying health conditions, as shown in Supplementary Table 3.

Discussion

In summary, approximately one-third of both vaccinated and unvaccinated participants demonstrated fair overall health literacy (33.11% and 37.84%, respectively). Participants enrolled in senior high school were significantly less likely to have received the HPV vaccine compared to those in junior high school. Interestingly, participants with low levels of knowledge and understanding were 66% more likely to be vaccinated than those with higher knowledge levels. Conversely, participants with low communication skills were 1.91 times more likely to be unvaccinated compared to those with high communication skills. These findings were adjusted for potential confounding factors, including education level, alcohol consumption, and underlying health conditions.

Our study found that approximately one-third of both vaccinated and unvaccinated adolescent participants demonstrated fair overall health literacy (33.11% and 37.84%, respectively). This suggests that general health literacy levels among adolescents remain moderate, regardless of vaccination status. The lack of significant difference in overall health literacy between groups implies that broad health knowledge alone may not be sufficient to influence HPV vaccine uptake. Instead, specific domains of health literacy such as knowledge and understanding or communication skills may play a more critical role in shaping vaccination behavior, indicating a need for more targeted health education interventions. The finding of moderate overall health literacy is supported by the demographic characteristics of the participants. A large proportion of the vaccinated group were senior high school students (61.48%), who are likely to have had more exposure to health education. However, even among this group, only one-third had more than a fair level of health literacy (33.11%), suggesting that exposure alone may not be sufficient. Subscale analysis revealed that while overall literacy was not a strong predictor of vaccine uptake, specific domains particularly knowledge and understanding were significantly associated with vaccination. This highlights the importance of deep, topic-specific education over general awareness.

Our findings are consistent with studies indicating that overall health literacy alone may not strongly influence HPV vaccination uptake, especially among adolescents. For example, a study found that while general health literacy was moderately associated with vaccine-related behaviors, domain-specific literacy, such as understanding HPV risks, had a stronger effect [26]. Similarly, a study reported that adolescents with higher HPV-specific knowledge but not necessarily high general health literacy were more likely to be vaccinated [27]. Conversely, some research suggests that overall health literacy is crucial for preventive behaviors. A meta-analysis showing that low health literacy is associated with poorer health outcomes and reduced engagement in preventive health services, including vaccinations [28]. This inconsistency may stem from differences in population, context, and the way health literacy is measured. Our study contributes to this literature by emphasizing that while general health literacy is important, tailored health education focusing on HPV-specific knowledge and decision-making is more effective in influencing vaccination behavior among adolescents.

Our multivariate analysis revealed that overall health literacy on cervical cancer and HPV vaccine was not significantly associated with HPV vaccination uptake among female adolescent, whether examined as a categorical or continuous variable (AOR = 0.92, 95%CI: 0.55-1.53; AOR = 1.00, 95%CI: 0.98-1.02, respectively). However, when analyzing specific subscales, knowledge and understanding were found to be significantly associated with vaccination (AOR = 0.34, 95%CI: 0.16-0.69). Participants with lower knowledge and understanding scores were significantly more likely to receive the HPV vaccine. This finding is somewhat counterintuitive, as greater knowledge is often expected to lead to higher vaccine uptake. It may suggest that adolescents with lower knowledge may rely more heavily on decisions made by parents, teachers, or healthcare providers, rather than their own understanding. This reinforces the influential role of external systems in facilitating vaccination behavior in adolescents. Demographic data support this interpretation. A higher proportion of vaccinated participants were enrolled in junior high school and were younger in age (13–15 years). At this developmental stage, adolescents may not yet possess strong comprehension or decision-making skills related to health, including HPV vaccination. Therefore, their vaccination decisions are likely driven by parental consent, school-based vaccination programs, or provider recommendations rather than their own knowledge. In contrast, older students in senior high school may seek more information and develop stronger personal opinions, potentially delaying or refusing vaccination based on perceived risks or misinformation.

Our finding that adolescents with lower knowledge and understanding were more likely to receive the HPV vaccine contrasts with many studies that emphasize the positive role of health knowledge in promoting vaccination. This inverse association may also reflect the effectiveness of school-based vaccination programs that do not require individual comprehension of HPV-related knowledge but instead rely on institutional policies and routine public health initiatives. Additionally, adolescents with lower health knowledge may be more passive in their healthcare decisions, leading to higher compliance with school-based vaccine campaigns or default parental consent, regardless of personal awareness. For example, a systematic review found that increased knowledge about HPV and cervical cancer was consistently associated with higher vaccine acceptance among both adolescents and their parents [29]. Similarly, a study reported that educational interventions that increased HPV-related knowledge significantly improved vaccine uptake [30]. However, our result aligns with findings from settings where structured programs and parental influence play a dominant role. A study highlighted that in school-based vaccination settings, adolescents often received the vaccine regardless of their personal knowledge, as parental consent and institutional support were the primary drivers [31]. These findings suggest that in contexts like Thailand, where school-based vaccination is common, external decision-makers can override individual knowledge gaps, leading to high vaccine coverage even among adolescents with limited understanding of HPV.

Our subscale analysis revealed a significant association between communication skills and HPV vaccination. Surprisingly, participants with lower communication skills were less likely to have received the HPV vaccine compared to those with higher communication skills (AOR = 1.91, 95%CI: 1.05-3.48). This highlights the critical role that effective communication plays in vaccine-related decision-making. Adolescents who are better able to express concerns, ask questions, and engage in health discussions may be more confident in accepting vaccination. In contrast, those with poor communication skills may struggle to seek information or express doubts, potentially leading to confusion, fear, or missed opportunities for receiving the HPV vaccine. Demographically, a larger proportion of unvaccinated participants were younger and enrolled in junior high school, suggesting that age and educational level may influence communication ability. Younger adolescents often have less-developed interpersonal and health communication skills, which may hinder their ability to actively participate in vaccine-related discussions or express understanding and consent. On the other hand, senior high school students, who demonstrated higher vaccination rates, likely possess more advanced communication competencies, enabling them to ask questions and engage with school staff or healthcare providers more confidently supporting the observed association between communication skills and HPV vaccine uptake.

Our findings align with existing literature showing that communication skills are a key factor in preventive health behaviors, including vaccination. For example, a study found that adolescents with better communication skills were more likely to discuss sexual health topics with healthcare providers and accept the HPV vaccine [32]. Similarly, a study emphasized that health communication competency directly influenced HPV vaccine acceptance among young adults, noting that the ability to ask questions and discuss health concerns empowered individuals to make informed vaccination decisions [26]. Additionally, a study highlighted that poor communication skills among adolescents often result in passive healthcare behaviors, making them more susceptible to vaccine hesitancy or refusal due to misinformation or fear [33]. These studies support our findings that effective communication facilitates trust, understanding, and confidence in vaccine decisions. Conversely, limited communication skills may create barriers to accessing reliable information or clarifying concerns, leading to reduced vaccine uptake. Our study reinforces the importance of incorporating communication skill-building into school-based health education to enhance adolescent engagement in vaccination programs.

Advantages and limitations of the study

This study offers several strengths. First, it provides valuable insights into the association between health literacy subscales and HPV vaccination among adolescent girls, a population that is often underrepresented in public health research. By using both categorical and continuous data, and adjusting relevant confounders, the study enhances the reliability of its findings. Additionally, the use of validated and pilot-tested questionnaires ensures good content validity and internal consistency. The inclusion of a balanced case-control design with systematic sampling for controls adds to the methodological rigor. The setting in real-world school environments also strengthens the study's relevance to public health practice, particularly in implementing school-based vaccination programs.

However, some limitations must be acknowledged. As a cross-sectional study, causal relationships cannot be established between the predictors and HPV vaccination. Self-reported data may also be subject to recall bias or social desirability bias, particularly concerning sensitive topics like sexual behavior or vaccination status. Furthermore, the study was conducted in a specific geographic area in southern Thailand, which may limit the generalizability of the findings to other regions or countries. Lastly, while health literacy was assessed, the influence of parental decision-making was not directly measured, which may play a significant role in adolescent vaccination behavior.

Implications of the study

The findings of this study highlight the importance of targeting specific components of health literacy particularly knowledge, understanding, and communication skills when designing interventions to improve HPV vaccination uptake among adolescents. While overall health literacy may not directly influence vaccination behavior, focusing on enhancing adolescents' comprehension of HPV and its prevention, as well as their ability to communicate

health concerns effectively, could increase vaccine acceptance. Moreover, the results suggest that educational level and age play a role in shaping health literacy and decision-making. These insights can inform public health strategies, school-based vaccination programs, and health education curricula to better tailor messages and delivery methods to adolescents' developmental stages and literacy needs. The findings highlight the need for school-based programs to go beyond HPV knowledge, focusing on enhancing adolescents' communication skills particularly their ability to seek, understand, and discuss vaccine-related information. Interactive modules, peer-led sessions, and communication training within health classes are recommended. These approaches can foster informed decision-making and improve vaccine acceptance in the supportive, accessible school environment.

In conclusion, this study explored the association between health literacy, social support, and HPV vaccination among adolescent girls in Chalerm Phrakiat District, Nakhon Si Thammarat Province. While overall health literacy was not significantly associated with HPV vaccination, subscale analysis revealed that specific components particularly knowledge and understanding were strongly linked to vaccine uptake. Interestingly, lower communication skills were also associated with higher vaccination rates, suggesting that external influences such as parental decisions or school health programs may play a crucial role among adolescents with limited communication ability. Educational level and age were also found to influence vaccination behavior, supporting the need for age-appropriate and school-based health interventions. These findings underscore the importance of tailored health education that strengthens specific health literacy skills rather than relying on general awareness. Targeted strategies addressing both cognitive and social determinants can enhance the effectiveness of HPV vaccination programs and contribute to the broader goal of cervical cancer prevention among adolescents. Integrating communication skill-building into school vaccination programs can improve dialogue, boost vaccine acceptance, and empower students' informed health decisions.

Author Contribution Statement

KB, MS, BC and SW conceptualized and designed the study. KB, MS, BC, and SW contributed to drafting the research proposal and conducting the literature review. Data collection and verification were carried out by KB, MS, KS, and SC. Data analysis and interpretation were performed by KB, MS, BC, SW and SM. The initial manuscript was drafted by KB and MS under the supervision of BC and SW. All authors reviewed and approved the final manuscript prior to submission.

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Ethical Considerations

This study was approved by the Human Research Ethics Committee of Thaksin University (COA No. TSU 2024_336, REC No. 0781) on December 10, 2024. The research was conducted in accordance with ethical guidelines, ensuring participant anonymity and the protection of all personal information. No identifiable data were collected or disclosed. Furthermore, the study was conducted in compliance with the ethical principles outlined in the Declaration of Helsinki and the Belmont Report, which emphasize respect for persons, beneficence, and justice in research involving human subjects.

Conflicts of interest

There are no conflicts of interest.

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