Adolescent Health Literacy in Hungary: A Cross-National Perspective Using the HELMA-H Instrument

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Background and Objective: Health literacy refers to the ability to access, understand, and apply health-related information to make informed health decisions. It is a critical determinant of individual and public health. This study aimed to assess the health literacy of Hungarian adolescents using the HELMA-H, the Hungarian adaptation of the Health Literacy Measure for Adolescents (HELMA), and to explore its associations with sociodemographic factors. Findings were also compared with results from similar studies conducted in Asia.

Materials and Methods: The cross-sectional study involved 747 students aged 16–19 (66.8% female) from high schools in Eger, Northern Hungary. Data were collected between January and February 2022 through an anonymous, self-administered online survey. The Questionnaire included demographic questions and the validated HELMA-H instrument (Cronbach's $\alpha = 0.96$). Due to non-normal data distribution, nonparametric tests (Mann–Whitney U and Kruskal–Wallis) were used. Statistical analysis was conducted using SPSS 25, with significance set at $\alpha = 0.05$.

Results: The mean HELMA score was 73.92 ± 16.66, indicating an "adequate" level of health literacy – higher than scores reported in comparable Asian studies. Maternal education was significantly associated with adolescents' health literacy, and paternal education also had a notable effect. No gender differences were observed, but 12th-grade students scored significantly higher than 11th graders.

Conclusion: The study confirms the validity of the HELMA-H tool in a European context and highlights cultural and regional influences on adolescent health literacy. It underlines the importance of addressing sociodemographic factors – especially parental education – in the design of targeted health education programs to improve adolescent health literacy in Hungary.

Keywords: Adolescent, Health Education, Health Literacy, HELMA-H, Socioeconomic Factors

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Introduction

Health literacy refers to an individual's ability to obtain, comprehend, and interpret health-related information and to utilize this knowledge in making informed decisions and judgments that influence personal and community health in everyday life (1,2,3). According to Nutbeam's model, health literacy can be categorized into three dimensions: functional health literacy, which encompasses the basic reading and writing competencies required to process health-related content; interactive health literacy, which involves more advanced cognitive and social skills that facilitate active engagement in health communication and decision-making; and critical health literacy, which entails the capacity to critically analyze and apply health information to exert greater control over one's health and broader determinants (4). In parallel, the integrated model developed by Sørensen et al. conceptualizes health literacy as comprising four interrelated competencies: accessing, understanding, appraising, and applying health information across domains such as healthcare, disease prevention, and health promotion (5).

Health literacy is widely recognized as a key determinant of individual and population health, as it equips individuals with the ability to engage with health information in ways that enhance personal health outcomes (6). It empowers people to make informed decisions that support health promotion for themselves, their families, and their communities (7,8). Empirical studies suggest that health literacy may serve as a stronger predictor of health status than age, income, ethnicity, or education (9,10). Reflecting its public health significance, the World Health Organization has identified health literacy as a central determinant of health equity (11). A growing body of evidence links limited health literacy with a broad spectrum of negative health outcomes, leading some scholars to describe it as a "silent epidemic" underlying many contemporary health challenges (12). Individuals with low health literacy are more likely to suffer from chronic conditions, engage in smoking and alcohol use, underutilize preventive services, and rely more heavily on curative care (13,14). Moreover, they tend to have difficulty interpreting health information, demonstrate reduced disease awareness (15), and experience higher rates of hospitalization, poorer treatment adherence, increased mortality, and inadequate management of chronic diseases (16,17). Low health literacy is also associated with unhealthy diets, elevated body mass index, risky behaviors including unprotected sex, and increased healthcare expenditures (18,19).

Although low health literacy is prevalent across all age groups (20,21), adolescents represent a particularly vulnerable population. As they transition into adulthood, high school students assume increasing responsibility for their health behaviors and decisions (22). Adolescence constitutes a critical developmental stage marked by rapid biological, psychological, and social changes, offering an opportune window for health literacy education and life skill development (23). Numerous studies underscore the long-term impact of adolescent health literacy on adult health outcomes, reinforcing the imperative for public health interventions aimed at fostering early health competence and autonomy (24). Despite the ubiquity of digital information sources, research indicates that adolescents often exhibit limited engagement with reliable health information, leading to knowledge gaps and low health literacy levels (25,26,27). Additional studies have also demonstrated that adolescents from vulnerable backgrounds, such as orphans, experience significantly lower levels of health literacy and quality of life, emphasizing the importance of social context (28).

Low health literacy in adolescence has been correlated with a range of adverse health behaviors, including poor dietary patterns, physical inactivity, risky sexual conduct, and substance use (29,30). These behaviors often become established during adolescence and persist into adulthood, contributing to the burden of non-communicable diseases (31,32).

In their Hungarian study using the Newest Vital Sign test (33). Tuza et al. (34) found that 45.83% of the participating Hungarian adolescents were likely to possess an adequate level of health literacy. In a subsequent study with a larger sample, this proportion increased to 50.49% (35). Compared to these earlier domestic findings, international studies have reported more favorable outcomes, with over 60% of respondents demonstrating adequate health literacy levels (33,36).

In a previous study of our own (37), we aimed to assess the level of health literacy among Hungarian secondary school students. We found that 18.0% of respondents demonstrated excellent, 53.1% adequate, 21.2% problematic, and 7.7% inadequate levels of health literacy. Overall, 71.1% of the surveyed students were classified as having a desirable level of health literacy, while 28.9% fell into the limited category.

To assess adolescent health literacy, several validated instruments have been developed. Among the most widely used are the Health Literacy Survey (HLS-EU-Q), which enables international comparisons across multiple domains; the Rapid Estimate of Adult Literacy in Medicine (REALM), a screening tool for medical vocabulary comprehension; and the Test of Functional Health Literacy in Adults (TOFHLA), which evaluates reading and numeracy skills related to health. A tool specifically tailored for adolescent populations is the Health Literacy Measure for Adolescents (HELMA), grounded in the theoretical frameworks of Nutbeam and Sørensen. The HELMA evaluates not only access and comprehension but also the application of health information, communication skills, and self-efficacy (38). The instrument has been adapted for use in Hungary as the HELMA-H, allowing for culturally contextualized assessment among Hungarian high school students (37).

The present study aims to comprehensively assess the health literacy levels of Hungarian adolescents using the HELMA-H instrument. Additionally, it seeks to explore the influence of sociodemographic variables on health literacy outcomes in order to identify key determinants. A further objective is to compare the findings of this first European application of the HELMA tool with existing Asian studies, thereby contributing to a deeper understanding of regional and cultural variations in adolescent health literacy.

Materials and Methods

Sample

In the course of the research, the population was defined as students attending full-time secondary grammar schools (gimnázium) located in the county seat of Hungary's Northeastern region (Eger), comprising five institutions. Among the different types of secondary schools, grammar schools were the least affected by the structural reforms of recent years. Furthermore, their primary objective is the most comprehensive: to provide a solid foundation of general education. The study included n = 747 students aged 16–19 years (66.8% girls), with a mean age of 17.22 ± 0.87 years. Participants were 11th (55.8%) and 12th (44.2%) grade students from five high schools located in the county seat of Northern Hungary (Eger). Regarding place of residence, 34.3% of students lived in the county seat, 15.5% in the city, and 50.2% in villages or rural areas. A detailed overview of the sample's demographic and parental educational characteristics is presented in **Table 1**. As for fathers' education, the majority had either vocational (30.8%) or secondary education (30.8%), followed by 27.4%

with university-level education. Only 2.1% had primary education, and 8.8% of fathers' education was reported as 'unsure.' Among mothers, 45.4% held a university degree, 29.2% had secondary education, and 15.9% had vocational training. A smaller proportion (3.1%) had primary education, and 6.3% of maternal education levels were reported as 'unsure.' One mother in the sample had not completed primary education.

Table 1. Sociodemographic Characteristics of the Study Sample (N = 747)

N=747			
		N	**%**
Gender	Male	248	33.2
	Female	499	66.8
Education level	11th grade	417	55.8
	12th grade	330	44.2
Father's Education Level	not completed	–	–
	Primary	13	2.1
	Vocational	230	30.8
	Secondary	230	30.8
	University	205	27.4
	Unsure	66	8.8
Mother's Education Level	not completed	1	0.1
	Primary	23	3.1
	Vocational	119	15.9
	Secondary	218	29.2
	University	339	45.4
	Unsure	47	6.3

Data Collection

The questionnaire consisted of two main sections. The first section included demographic questions adapted from the HBSC[1] survey, covering gender, age, grade level, parental background, living environment, and academic characteristics.

The second section comprised the validated HELMA-H questionnaire (Cronbach's α = 0.96), which assesses functional, interactive, and critical dimensions of health literacy (14). The first 41 items were rated on a 5-point Likert scale ("never," "rarely," "sometimes," "usually," "always") and measured domains such as self-efficacy, access, reading, understanding, evaluation, application, and communication, with 4 to 10 items per domain. The final three items, related to numeracy, required short-answer responses involving basic mathematical operations.

[1] Health Behaviour of School-aged Children

Based on total scores, respondents were classified into four health literacy levels:

- Excellent (84.01–100),
- Adequate (66.01–84),
- Problematic (50.01–66), and
- Inadequate (0–50).

The *excellent* and *adequate* categories together indicate a desirable level of health literacy, while the *problematic* and *inadequate* categories together represent a limited level. From the reporting practices of international research, we can see that, in addition to categorical distributions of health literacy, some researchers also use mean scores as a basis (28,39,40).

Data Processing and statistical analysis

Prior to statistical analysis, a data cleaning procedure was performed to enhance data quality. Out of 761 completed responses, 14 were excluded due to missing answers (N = 10) or systematic response patterns (e.g., identical responses across all items; N = 4).

To assess the normality of continuous variables, the Shapiro–Wilk test was applied. Since none of the dependent variables followed a normal distribution, nonparametric statistical methods were used for further analysis.

Descriptive statistics, including means and standard deviations, were calculated for each dimension and total score of the HELMA-H instrument. Inferential analyses were conducted using the Mann–Whitney U test to examine differences by gender and grade level, and the Kruskal–Wallis test to evaluate the effect of parental educational background on health literacy scores.

All statistical analyses were performed using IBM SPSS Statistics for Windows, version 25 (Chicago, IL, USA). A significance level of $\alpha = 0.05$ was used in all tests.

The findings of the present study were evaluated in comparison with previous international research, applying a ranking-based analytical approach. The inclusion criteria for the comparative analysis were as follows: (1) publication between 2016 and 2024, (2) application of the HELMA instrument for the assessment of health literacy, (3) utilization of HELMA-based categorical classifications, and (4) full-text availability in an online format. All studies meeting these criteria were included in the comparative analysis. Based on the available data, such comparisons can be approached in two primary ways: first, by examining the distribution of

participants across predefined percentage-based health literacy categories, and second, by analyzing the average scores achieved on the HELMA instrument.

Results

Among the surveyed students, 31.2% demonstrated an excellent level of health literacy, 42.6% were classified as having an adequate level, 17.8% fell into the problematic category, and 8.4% were identified as having inadequate health literacy. Overall, 73.8% of participants exhibited a desirable level of health literacy—defined as either excellent or adequate—while 25.2% were categorized within the limited level, comprising those with problematic or inadequate health literacy. In terms of gender distribution across the HELMA-H categories, 33.5% of students with excellent scores were male and 66.5% were female. Among those in the adequate category, 32.5% were male and 67.5% were female. Similarly, 32.8% of students with problematic health literacy were male and 67.2% female, while the inadequate group comprised 33.3% male and 66.7% female participants. Within the desirable health literacy category, 24.2% of the total sample were male (n = 181) and 49.5% were female (n = 370). In contrast, among those in the limited category, 8.7% were male (n = 65) and 17.5% were female (n = 131).

Analysis by grade level revealed that among students with excellent health literacy, 51.5% were in 11th grade (n = 120) and 48.5% in 12th grade (n = 113). Within the adequate category, 55.7% were 11th graders (n = 177), while 44.3% were in 12th grade (n = 141). Of those classified as having problematic health literacy, 61.7% were in 11th grade (n = 82) and 38.3% were in 12th grade (n = 51). Among those with inadequate health literacy, 60.3% were 11th graders (n = 38) and 39.7% were in 12th grade (n = 25). Overall, 53.9% of the total sample consisted of 11th-grade students (n = 297), and 46.1% were 12th graders (n = 254). Within the desirable category, 61.2% were in the 11th grade (n = 120), while 38.8% were in the 12th grade (n = 76).

The mean total HELMA-H score in the present study was 73.92 (SD = 16.66) out of a possible 100, indicating an overall adequate level of health literacy among participants. When comparing genders, males scored slightly higher on average (M = 74.17, SD = 17.14) than females (M = 73.79, SD = 16.43), though the difference was not statistically significant (p = 0.642). In contrast, grade-level comparisons revealed that 12th-grade students achieved significantly higher scores (M = 75.46, SD = 16.66) compared to those in the 11th grade (M =

72.70, SD = 16.60), with the difference reaching statistical significance (p = 0.014), suggesting that health literacy may improve with age and educational progression. A detailed comparison of mean scores by gender and grade across all HELMA-H dimensions is presented in **Table 2**, where statistically significant differences are highlighted in bold for ease of interpretation.

Table 2. Comparison of Health Literacy Dimensions by Gender and Grade Level (N = 747)

N = 747		Mean	SD	p-Value*
Self-efficacy	Male	15/99	3/02	0/716
	Female	16/04	3/03	
	11th grade	**15/71**	**3/04**	**0/001**
	12th grade	**16/42**	**3/02**	
Access	Male	20/33	4/11	0/964
	Female	20/27	4/24	
	11th grade	**20/02**	**4/15**	**0/013**
	12th grade	**20/63**	**4/20**	
Reading	Male	20/40	4/00	0/421
	Female	20/54	4/15	
	11th grade	20/40	3/98	0/220
	12th grade	20/61	4/10	
Understanding	Male	42/10	7/83	0/920
	Female	42/25	7/40	
	11th grade	**41/69**	**7/72**	**0/043**
	12th grade	**42/84**	**7/54**	
Appraisal	Male	20/56	4/19	0/142
	Female	20/10	4/26	
	11th grade	**19/93**	**4/29**	**0/013**
	12th grade	**20/66**	**4/24**	
Use	Male	14/35	4/19	0/870
	Female	14/49	3/88	
	11th grade	14/34	3/95	0/478
	12th grade	14/57	3/98	
Communication	Male	31/74	6/88	0/102
	Female	31/04	6/59	
	11th grade	**30/84**	**6/57**	**0/031**
	12th grade	**31/82**	**6/69**	
Numeracy	Male	9/05	3/91	0/791
	Female	9/14	4/03	
	11th grade	8/99	3/92	0/415
	12th grade	9/25	3/99	
Total Helma	Male	74/17	17/14	0/642
	Female	73/79	16/43	
	11th grade	**72/70**	**16/60**	**0/014**

	12th grade	**75/46**	**16/66**	

*Mann-Whitney U test

Further examination of specific HELMA-H dimensions showed that for self-efficacy, there were no significant differences between males and females (p = 0.716), although 12th graders scored significantly higher than their 11th-grade counterparts (16.42 vs. 15.71; p = 0.001). In the access dimension, gender differences were also non-significant (p = 0.964), but 12th-grade students again scored significantly higher (20.63 vs. 20.02; p = 0.013). No statistically significant differences were observed in the reading dimension with respect to either gender (p = 0.421) or grade level (p = 0.220). In the understanding domain, gender differences were not significant (p = 0.920), but 12th-grade students achieved significantly higher scores than those in the 11th grade (42.84 vs. 41.69; p = 0.043). For the appraisal dimension, although no significant difference was found between genders (p = 0.142), students in the 12th grade scored significantly higher than those in the 11th (20.66 vs. 19.93; p = 0.013). In the use dimension, neither gender (p = 0.870) nor grade level (p = 0.478) differences reached statistical significance. Within the communication dimension, gender differences remained non-significant (p = 0.102), though a significant difference emerged by grade level, with 12th graders scoring higher than their younger peers (31.82 vs. 30.84; p = 0.031). Finally, in the numeracy domain, no significant differences were found by gender (p = 0.791) or grade (p = 0.415). Taken together, the findings suggest that gender is not a significant predictor of health literacy levels or its sub-dimensions among secondary school students. However, students in the 12th grade consistently outperformed those in the 11th grade across several domains, with statistically significant differences observed in self-efficacy, access, understanding, appraisal, and communication.

Health literacy scores showed a positive association with maternal education levels. Students whose mothers held a university degree achieved the highest average score in the self-efficacy dimension (M = 16.20), while those whose mothers had only primary education recorded the lowest (M = 14.48). In the access domain, the highest mean score was observed among students whose mothers had completed secondary education (M = 20.49), with the lowest again found among those with primary-educated mothers (M = 18.83). A similar trend was evident in the reading domain, where students with university-educated mothers scored the highest (M = 20.61), compared to the lowest score among students with mothers with primary

education (M = 18.61). For the understanding dimension, the highest average score was associated with secondary education (M = 42.92), while the lowest (M = 38.00) was linked to primary education. In the appraisal dimension, students whose mothers had secondary education achieved the highest score (M = 20.57), while those with primary-educated mothers again recorded the lowest (M = 18.91).

In the use dimension, students with university-educated mothers scored the highest (M = 14.60), whereas students whose mothers had only primary education scored the lowest (M = 13.00). This pattern was also observed in the communication dimension, with the highest score among students with university-educated mothers (M = 31.70), and the lowest among those with primary-educated mothers (M = 28.30). For numeracy, the highest score was reported by students whose mothers had completed secondary education (M = 9.29), and the lowest by those whose mothers had only primary education (M = 8.10).

Regarding the total HELMA score, students whose mothers had secondary education achieved the highest overall mean (M = 75.03), while those with primary-educated mothers scored the lowest (M = 65.77). These differences were statistically significant (p = 0.003), indicating that maternal education is a meaningful determinant of adolescents' health literacy levels in this sample. A comprehensive summary of the associations between both maternal and paternal education and adolescents' health literacy is provided in **Table 3**, where statistically significant results are highlighted in bold for ease of interpretation.

Table 3. Mean and Standard Deviation of Total Health Literacy Scores by Parents' Education Level

Mother's Education Level		**Total Helma Score**	**Test statistic**	**P-Value**
not completed	M	69/90	**7/476**	**0/003****
	SD	.		
Primary	M	65/77		
	SD	21/72		
Vocational	M	72/97		
	SD	17/44		
Secondary	M	75/03		
	SD	14/88		
University	M	74/59		
	SD	16/84		
Unsure	M	70/37		
	SD	17/61		
Total	**M**	**73/92**		
	SD	**16/66**		
Father's Education Level		**Total Helma Score**	**Test statistic**	**P-Value**
	M	71/06	15/847	**0/003****

not completed	SD	19/17		
Primary	M	74/71		
	SD	17/17		
Vocational	M	74/60		
	SD	14/99		
Secondary	M	74/77		
	SD	17/26		
University	M	66/83		
	SD	16/59		
Unsure	M	73/92		
	SD	16/66		
Total	**M**	**71/06**		
	SD	**19/17**		

**Kruskal-Wallis Test

The relationship between paternal education and health literacy scores follows a pattern broadly consistent with that observed for maternal education. In the self-efficacy dimension, students whose fathers had completed vocational education reported the highest average score (M = 16.40), while those whose fathers had not completed any formal education showed the lowest (M = 14.81). Similarly, in the access domain, vocational education was associated with the highest mean score (M = 20.38), and the lowest (M = 19.00) was again recorded among students whose fathers had incomplete education. In the reading domain, the highest average score was observed among students whose fathers had completed secondary education (M = 20.69), while the lowest was found among those with no completed education (M = 20.00).

Interestingly, in the understanding domain, students with vocational-educated fathers achieved the highest score (M = 42.63), whereas those with university-educated fathers had the lowest (M = 39.12). A similar pattern emerged in the appraisal dimension, where students with vocational-educated fathers again reported the highest scores (M = 20.44), while those with university-educated fathers had the lowest (M = 18.71). In the use dimension, vocational education was once more associated with the highest average (M = 14.35), in contrast to university education, which corresponded to the lowest score (M = 13.84). This trend was also evident in the communication domain, where students whose fathers had vocational education achieved the highest mean score (M = 31.08), while those with university-educated fathers scored the lowest (M = 28.47). For numeracy, vocational education again yielded the highest average (M = 9.44), and university education was linked to the lowest (M = 8.32).

When examining the total HELMA score, students whose fathers had completed secondary education achieved the highest overall mean (M = 74.77), whereas the lowest total score (M = 66.83) was observed among students whose fathers had attained university-level education. These differences were statistically significant (p = 0.003), suggesting that paternal education is significantly associated with adolescents' health literacy in this sample, though not always in a linear or expected direction.

Drawing on available international HELMA data, an initial comparative analysis using percentage categories allows for meaningful insights into regional differences in health literacy outcomes. A detailed summary of these international findings is presented in **Table 4**, where the present Hungarian study is highlighted in bold to facilitate clear identification within the ranking.

Table 4. Prevalence of HELMA Levels Across Different Studies and Regions

Study (year of publication)	N	Country/Region	Prevalence of Desirable level (%)	Prevalence of Limited level (%)	Ranking in HELMA
Keikha et al. (2021)	200	Zahedan	98.3-98.5	1.7-1.5	1.
Varmazyar et al. (2024)	1117	Tabriz, Iran	75.8	24.2	2.
This study (2025)	**747**	**Hungary**	**73.8**	**25.2**	**3.**
Dehghankar et al. (2019)	372	Quazin, Iran	63.4	36.6	4.
Vashe et al. (2022)	315	Malaysia, Sri Lanka	47.7	52.3	5.
Kayalkar & Dmello (2024)	421	Amravati, Maharashtra, India	38.2	61.8	6.
Huang et al. (2023)	777	Hong Kong	25.6	74.4	7.

Dehghankar et al. reported that 36.6% of Iranian adolescents exhibited limited health literacy, while 63.4% achieved levels categorized as desirable (40). In another Iranian study, conducted in the context of an intervention, the proportion of adolescents with desirable health literacy was exceptionally high, reaching 98.3% at baseline and increasing slightly to 98.5% post-intervention, with only 1.7% and 1.5% classified as having limited literacy before and after the intervention, respectively (41). According to the most recent Iranian data, 75.8% of adolescents demonstrated desirable health literacy, while 24.2% fell into the limited category (42). Outside of Iran, findings vary significantly. In Malaysia and Sri Lanka, 47.7% of participants were classified as having desirable health literacy, compared to 52.3% with limited levels (43). In India, the proportion of desirable health literacy was lower still, at 38.2%, with 61.8% categorized as limited (44). The lowest rate of desirable health literacy was

recorded in Hong Kong, where only 25.6% met the threshold, while 74.4% were considered to have limited health literacy (45).

Among these studies, the highest proportion of desirable health literacy was reported by Keikha et al. (41) in Iran, and the lowest by Huang et al. in Hong Kong (45). The results of the present Hungarian study, with 73.8% of students falling into the desirable category, rank third overall, following the Iranian studies, and exceeding the outcomes observed in Malaysia, Sri Lanka, India, and Hong Kong.

Based on the available data from studies using the HELMA instrument, further insights can be gained by comparing not only the categorical distributions, but also the mean scores achieved across different populations. A summary of these comparative findings is presented in **Table 5**, where the present Hungarian study is highlighted in bold to facilitate its identification within the ranking.

Table 5. HELMA Scores and Rankings Across Different Studies and Regions

Study (year of publication)	N	Counrty/Region	HELMA Score	Ranking
This study (2025)	**747**	**Hungary**	**73.92 ± 16.66 (adequate)**	**1.**
Roodposhti et al. (2021)	232	Tehran, Iran	63.8 ± 16.8 (problematic)	2.
Hasanatuludhiyah et al. (2023)	432	Indonesia	63.1 (problematic)	3.
Karimi et al. (2020)	370	Tehran, Iran	59.92 ± 12.87 (problematic)	4.

Two studies conducted in Tehran reported average HELMA scores within the problematic range. The earlier study recorded a mean score of 59.92 (SD = 12.87), while a subsequent investigation found a slightly higher average of 63.8 (SD = 16.8), though this too remained within the problematic category (39,28). Similarly, a study conducted in Indonesia yielded an average score of 63.1, again falling into the problematic range (41). In contrast, the present Hungarian study demonstrates a more favorable outcome, with an average HELMA-H score of 73.92 (SD = 16.66), placing participants within the “adequate” health literacy category.

Among the reviewed international studies utilizing the HELMA instrument, the Hungarian study stands out as the only one reporting mean scores in the adequate range. The remaining studies from Asia consistently reflect problematic levels, indicating a need for substantial improvement in adolescent health literacy across those regions. While variability exists among the Asian findings, the general trend suggests that limited or problematic health literacy is prevalent.

Discussion

A total of 747 high school students aged 16–19 years participated in the study from five schools in Northern Hungary (66.8% female, mean age 17.22 years). Of the sample, 55.8% were in 11th grade and 44.2% in 12th grade. In terms of sociodemographic background, parental education emerged as a key factor: 45.4% of mothers and 27.4% of fathers held a university degree.

Data collection was carried out using the validated HELMA-H questionnaire (Cronbach's α = 0.96), which measures the functional, interactive, and critical dimensions of health literacy. Based on total scores, respondents were classified into four categories: excellent, adequate, problematic, and inadequate. Nonparametric statistical tests (Mann–Whitney U, Kruskal–Wallis) were applied in the analyses.

Results showed that 31.2% of students demonstrated excellent, 42.6% adequate, 17.8% problematic, and 8.4% inadequate health literacy. Overall, 73.8% fell into the desirable category (excellent or adequate), while 25.2% were classified as limited (problematic or inadequate). The mean HELMA-H score of the total sample was 73.92 (SD = 16.66), indicating an "adequate" level. No significant gender differences were observed, whereas 12th-grade students scored significantly higher than those in 11th grade ($p = 0.014$). Subgroup analyses further confirmed that older students performed better in several dimensions (self-efficacy, access, understanding, appraisal, communication).

Parental education showed a strong association with health literacy: maternal education emerged as a particularly significant determinant ($p = 0.003$), while paternal education also proved relevant, though in some dimensions the relationship was not linear.

To date, the HELMA tool has been primarily applied in Asian contexts, while the present study represents one of the first applications of the validated HELMA-H instrument in Europe, specifically in Hungary (37). In Asian countries, HELMA is widely used, and existing findings almost exclusively derive from that region. This geographic contrast provides a unique opportunity to compare health literacy levels across different cultural and educational environments.

The Hungarian students' results proved favorable in the international comparison: the proportion of desirable health literacy (73.8%) ranked third after Iran (42) and was significantly higher than the rates reported in Malaysia, Sri Lanka (43), India (44), and Hong Kong (45). Based on both categorical and mean-score comparisons, the Hungarian sample was the only one to fall within the "adequate" range, while most Asian studies reported problematic levels.

These cross-country differences highlight the significant influence of geographical location, cultural background, and socio-economic factors on adolescents' health literacy.

The findings confirm that the HELMA-H is a valid and reliable tool among Hungarian high school students. The study underscores the importance of parental education – particularly that of mothers – as well as the positive association of age and academic progression with health literacy. The international comparison further emphasizes the role of cultural and regional factors in shaping health literacy outcomes.

The novelty of this research lies in being the first to apply the HELMA instrument in a European setting, specifically in Hungary. The mean score of 73.92 (SD = 16.66) not only indicates a higher level of health literacy among Hungarian adolescents but also confirms the validity of the HELMA-H tool outside of Asia (37). The results highlight the substantial role of cultural, educational, and socio-economic factors in shaping health literacy outcomes.

Moreover, the study supports growing evidence that health literacy is closely linked to sociodemographic characteristics. Previous Iranian research found significantly lower health literacy levels among females compared to males (42), whereas other studies, such as Huang et al. (45) in Hong Kong, reported no gender differences. Consistent with the latter, the Hungarian findings showed no statistically significant gender differences in overall health literacy or its subdomains.

With respect to grade level, Keikha et al. reported that first-year Iranian high school students demonstrated higher health literacy than their second-year peers (41). In contrast, Vashe et al. found that younger students scored lower than older ones (43). The Hungarian results support the latter: 12th-grade students exhibited significantly higher levels of health literacy than 11th graders, suggesting a positive correlation between age, academic progression, and health literacy.

Parental education, especially maternal education, consistently emerged as a key determinant of adolescent health literacy. Prior studies (40,42,41) have shown that children of university-educated mothers achieve higher levels of health literacy. The present findings reinforce this trend, highlighting a strong association between maternal education and adolescent health literacy in Hungary. Notably, the study also emphasizes the role of paternal education, which has been less frequently examined in the literature, yet appeared as a relevant factor influencing health literacy levels in the Hungarian context.

Study Limitations and Strengths: This study has several limitations that should be considered when interpreting the results. First, the sample was drawn from a single county seat (Eger) in Northern Hungary, which may limit the generalizability of the findings to other regions of the country or to different European contexts. Although the sample size was adequate, the results may not reflect the health literacy levels of adolescents in more diverse urban or rural populations. Second, the study relied on self-reported data collected through an online questionnaire, which may be subject to response bias, social desirability, or misunderstanding of items. Third, the cross-sectional design prevents the establishment of causal relationships between variables. Longitudinal studies would be necessary to explore the development of health literacy over time.

Despite these limitations, the study provides valuable insights into adolescent health literacy in a European setting and supports the cross-cultural applicability of the HELMA-H instrument. However, caution should be exercised when generalizing the findings beyond the studied population, and further research involving broader and more diverse samples is recommended.

Conclusion

This research not only demonstrates the successful adaptation and application of the HELMA-H instrument within a European context, but also provides valuable insights for the further development of strategies aimed at improving health literacy. The findings confirm that health literacy is closely associated with various sociodemographic factors, particularly gender, age, and – most significantly – parental educational attainment.

Based on the results of the present study, several practical recommendations can be formulated for the targeted development of health literacy among Hungarian secondary school students. While Hungarian adolescents performed favorably in international comparisons, significant disparities were observed within the population along sociodemographic lines. These variations underscore the need for tailored intervention strategies.

Primarily, it is recommended to design grade-specific health education programs, as the data clearly indicate that 12th – grade students achieved significantly higher scores than their 11th-grade peers in the dimensions of self-efficacy, access, understanding, appraisal, and communication. This suggests a progressive improvement in health literacy with age and academic advancement, highlighting the importance of initiating preventive interventions in earlier grades.

Parental – especially maternal – education level showed a statistically significant correlation with students' health literacy, supporting the notion that the family environment functions as a major social determinant of young people's health knowledge and competencies. Accordingly, it is advisable to develop programs that directly involve parents in school-based health education, with particular attention to families with lower educational backgrounds. For these groups, health information should be made accessible through appropriate language and communication channels.

Furthermore, the study revealed that students generally demonstrated low competency levels in the "use" and "numeracy" dimensions of health literacy, regardless of gender or grade level. This points to the need for implementing practice-oriented and interactive pedagogical methods – such as project-based learning, simulations, and exercises modeling real-life health decisions – within the curriculum. To improve numerical health literacy, it is recommended to regularly incorporate health-related quantitative exercises into mathematics and biology instruction.

It is also important to emphasize the necessity of developing digital health literacy, particularly given the significant grade-level differences observed in students' ability to access health-related information. This can be addressed by teaching students to critically evaluate online

content and identify credible sources. In this context, strengthening communication skills is also essential, especially in terms of conveying reliable information and engaging in effective dialogue with health professionals. Activities such as debates and role-playing exercises can support these objectives.

Finally, the regular application of the HELMA-H instrument at the school level would provide a valuable tool for monitoring students' health literacy and evaluating the effectiveness of interventions over time. Data-driven local action plans, developed based on measured results, could assist schools in crafting targeted, evidence-based health education strategies that account for age, academic level, and sociocultural background.

Moreover, the comparative analysis with studies conducted in Asian countries highlights the critical importance of using culturally and regionally appropriate tools and methodologies when assessing and promoting health literacy. As the first study to employ the HELMA framework in a European context, this research not only lays the groundwork for future investigations in similar settings but also serves as a key reference point for cross-regional comparative analyses based on standardized instruments such as HELMA.

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Their involvement supports a deeper understanding of adolescent health literacy and contributes to the development of future educational interventions aimed at promoting health-conscious behaviors.

Availability of Data and Materials: The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Conflicts of interest: The authors declare that they have no competing interests.

Consent for publication: Not applicable.

Ethics Approval and Consent to Participate: This study was conducted in accordance with the Declaration of Helsinki; The study was conducted with the approval of the Research Ethics Committee of Eszterházy Károly Catholic University in Eger, Hungary. Prior to data collection, all participants received detailed information about the purpose, procedure, and data management of the research. Students participated voluntarily and anonymously, with the informed consent of their parents or legal guardians, as well as the approval of their respective schools.

Before completing the questionnaire, students were provided with an informed consent form, which clearly stated that their participation was voluntary, could be withdrawn at any time without justification, and that their responses would be treated confidentially and used solely for research purposes. All data were processed confidentially and fully anonymized in accordance with data protection regulations.

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