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Digital health literacy among undergraduate nursing students in China: associations with health lifestyles and psychological resilience

Linfeng Liu¹, Mengxue Fu², Jijun wu³, Hongyan Wang¹, Jiaorong Zhao⁴, Pei Chen⁴, Jun Cao¹, Wen Zhang¹, Qin Lin^{4*} and Ling Li^{4*}

Abstract

Background Digital health literacy (DHL) is pivotal for individuals to access trustworthy health information and make informed decisions, closely intertwined with health behaviors and psychological resilience—these factors collectively shape an individual's approach to health management. Despite extensive research on digital health literacy in broader populations, the specific dynamics of digital health literacy in relation to health behaviors and psychological resilience among undergraduate nursing students in China remain understudied, highlighting a gap that this research endeavors to address. This study aims to assess the levels of digital health literacy among undergraduate nursing students in China, and to explore its association with health lifestyles and psychological resilience, which are considered influential factors.

Methods Employing a descriptive cross-sectional research design, eligible Chinese nursing undergraduates were surveyed from June to October 2023. This study recruited a total of 418 undergraduate nursing students. After excluding 11 students on leave, 407 students participated in questionnaire completion and submission. The College Students' Digital Health Literacy Scale, Healthy Lifestyle Assessment Scale and The Psychological Resilience Scale were used in this study.

Results The mean scores for digital health literacy, health lifestyles, and psychological resilience were 74.78 ± 8.44 , 127.14 ± 11.22 , and 79.21 ± 11.02 , respectively. Pearson correlation analysis results indicated that the correlations between digital health literacy and both health lifestyles ($r=0.707$, $P<0.01$) and psychological resilience ($r=0.638$, $P<0.01$) were statistically significant and positive. The multiple linear regression analysis revealed that volunteer activity experience, academic performance, physical fitness, psychological traits, health lifestyle, and psychological resilience significantly predicted digital health literacy ($F=58.091$, $P<0.001$, $R^2=0.678$, adjusted $R^2=0.666$).

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Specifically, excellent academic performance ($\beta=0.210, P<0.001$) and good physical fitness ($\beta=0.188, P=0.002$) were the strongest predictors of higher digital health literacy.

Conclusions There is a correlation between the digital health literacy of nursing undergraduates and their health lifestyles and psychological resilience. Future research should consider interventions in digital health literacy for undergraduate nursing students in China from the perspectives of health lifestyles and psychological resilience.

Keywords Nursing, Undergraduates, Digital health literacy, Health lifestyles, Psychological resilience

Background

Digital health literacy (DHL), a critical competency in the modern healthcare landscape, refers to an individual's ability to access, comprehend, evaluate, and apply health-related information obtained through digital technology [1]. This concept encompasses not only technical skills but also the capacity to discern credible health information, underscoring its significance in informed decision-making and self-care practices [2]. Digital health literacy is a multifaceted skill set that is becoming increasingly integral to nursing education and practice [3, 4]. Given the rapid digital transformation in healthcare, undergraduate nursing students must develop these competencies to effectively engage with digital health tools and resources [5, 6]. Digital health literacy empowers nursing students to adapt to and utilize evolving technologies, promoting health management and the delivery of quality nursing care [7, 8]. Digital health literacy involves not only proficiency in using technology but also understanding the scientific, credible, and applicable nature of health information to support clinical decision-making and patient education [9]. Research on digital health literacy among undergraduate nursing students is crucial in understanding their adaptability to digital technology, information retrieval and utilization behaviors, and awareness of digital healthcare resources. This aids in developing educational plans, training courses, and resources to enhance the level of digital health literacy among undergraduate nursing students, better addressing the needs and challenges in future healthcare [10].

Health lifestyles, encompassing dietary habits, exercise, sleep quality, and stress management [3, 11]. These lifestyle choices of nursing students are crucial for their personal health, their capacity to care for future patients, and promoting patient health [12]. Healthy lifestyles offer multiple benefits to students in the nursing profession. Firstly, maintaining good health habits helps in improving students' physical health, enhancing immunity, and reducing the risk of illnesses [13]. Additionally, good health practices aid in improving students' mental well-being, reducing stress and anxiety, thereby enhancing learning and work efficiency [14]. Cultivating healthy lifestyles among nursing students is crucial for future clinical practice and patient care. Nursing students with good lifestyle habits can serve as healthy role models,

better understand and impart correct health behaviors to patients, promoting patient self-management and recovery [15]. Studying the health lifestyles of undergraduate nursing students is crucial in understanding their current behavior patterns, recognizing the impact on their physical and mental health, and developing intervention measures. This will aid in conducting relevant health promotion plans and educational programs to encourage and support nursing students in adopting healthy lifestyles, ultimately improving their personal health levels and influencing the health outcomes of future patients [16]. Moreover, the health behaviors and lifestyle choices of nursing students play a crucial role not only in their personal well-being but also in their ability to promote healthy practices among future patients. Understanding the factors that influence these behaviors is integral to fostering a culture of wellness and disease prevention [17].

Psychological resilience, the capacity to adapt and recover from adversity, is particularly pertinent for nursing students who will encounter challenging situations in their studies and careers [18, 19]. In the context of nursing education, psychological resilience is fundamental for students. It empowers them to navigate the rigors of their training, cope with academic stress, and prepare for the emotional demands of patient care [20]. Resilient nursing students are better equipped to handle the emotional complexities inherent in the healthcare environment, ensuring the delivery of high-quality and compassionate care to patients [21]. Research in this area not only enhances our understanding of the challenges encountered by nursing students but also informs the development of targeted interventions and resilience-building programs. Such initiatives are essential for nurturing mental fortitude and emotional well-being among nursing students throughout their academic and professional development. Moreover, by considering the insights from clinical practice and patient contributions alongside those of nursing students, psychological resilience research fosters a comprehensive approach to education and support mechanisms that benefit all parties involved in the healthcare ecosystem [22, 23].

In the context of digital health literacy, it is recognized as a multifaceted skill set that is becoming increasingly integral to nursing education and practice. There is a

burgeoning recognition that digital health literacy can significantly influence health lifestyles. For instance, students with higher digital health literacy may be more adept at using digital platforms to access health information, track their behaviors, and make informed lifestyle choices [24, 25]. Research indicates that individuals with higher digital health literacy are more likely to understand how to improve their lifestyle habits through healthy eating, regular exercise, and adopting new health behaviors such as smoking cessation, limited alcohol consumption, and maintaining appropriate weight [26, 27]. Furthermore, digital health literacy contributes to enhancing psychological resilience by providing mental health resources and self-help tools, especially when facing stress and adversity [28, 29]. In terms of education and professional preparation, digital health literacy is crucial for nursing students as it relates to their capabilities as future health professionals and their role in educating patients and community members to promote healthy lifestyles and psychological resilience [30]. Social support and online communities are also vital components of digital health literacy, aiding in maintaining healthy lifestyles and psychological resilience, particularly in times of isolation and stress [31]. Therefore, digital health literacy serves as a bridge connecting healthy lifestyles and psychological resilience, and is essential for cultivating a new generation of nursing professionals who are well-equipped to navigate the complexities of modern healthcare.

Understanding these connections can offer insights into the development of targeted interventions and educational strategies to enhance the overall well-being of future nursing professionals. This study aims to assess the levels of digital health literacy among undergraduate nursing students in China, and to explore its association with health lifestyles and psychological resilience, which are considered influential factors. Undergraduate nursing students represent a pivotal population for this study for several reasons. Firstly, as future healthcare professionals, they are at the forefront of integrating digital technologies into patient care, education, and management [32, 33]. Their proficiency in digital health literacy is, therefore, directly linked to the quality of care they will provide. Secondly, the nursing curriculum provides a unique opportunity to instill and enhance digital health literacy skills, preparing students to meet the demands of an increasingly digital healthcare system [34, 35]. Despite the growing importance of digital health literacy, there is a dearth of research focusing on undergraduate nursing students in China. This study aims to fill this gap by assessing the current levels of digital health literacy among this demographic and exploring the interplay between digital health literacy, health lifestyles, and psychological resilience. By doing so, we aim to contribute

to the body of knowledge and inform educational strategies that can equip nursing students with the necessary skills to navigate the digital aspects of healthcare. The significance of this study lies in its potential to influence nursing education and practice. By understanding the digital health literacy landscape among nursing students, educators can tailor curricula to enhance these skills. Additionally, recognizing the correlation between digital health literacy and other critical factors such as health lifestyles and psychological resilience can lead to holistic development programs that foster well-rounded nursing professionals.

Methods

Study design

A descriptive cross-sectional study was conducted involving undergraduate nursing students from two (2) different universities in China.

Sampling and study participants

The target population for this study comprises undergraduate nursing students enrolled in two nursing colleges in Chengdu and Hangzhou, China. Nursing students from the first to fourth grades at these two colleges were invited to participate. Both colleges, selected for their diverse student populations and representativeness of educational standards in China, are situated in provincial capital cities. These locations provide a rich socioeconomic context, which may contribute to the variability in digital access and health literacy levels among the student body. The inclusion of these institutions is intended to capture a spectrum of experiences that reflect the broader nursing student demographic in the country. In alignment with the standard calculation methods for sample size in observational studies, the ideal sample size is determined to be 5 to 10 times the count of independent variables. This study encompassed a comprehensive set of 24 independent variables, including 10 socio-demographic profiles, 3 dimensions for digital health literacy, 8 dimensions for health lifestyle, 3 dimensions for psychological resilience. Consequently, the calculated sample size ranged from 120 to 240 participants. To account for potential invalid responses, which were conservatively estimated at 10%, the required sample size was adjusted to a range of 132 to 264. Therefore, the study aimed to achieve a minimum sample size of 132 to ensure robust and reliable findings. The research participants were strategically chosen through a cluster sampling method, prioritizing ease of access and alignment with the study's scope. To attain an adequate sample size, a random selection of five classes from each university was made, thereby ensuring a representative cross-section of the student population for the study's purposes. Inclusion criteria: (1) Full-time registered nursing

undergraduates; (2) Informed consent and voluntary participation in the study. Exclusion criteria: Participants unable to complete the survey in its entirety.

Survey tools

Composition of the Survey

The survey included informed consent form, demographic questionnaire, digital health literacy scale, healthy lifestyle assessment scale, and psychological resilience scale.

Demographic questionnaire

The demographic characteristics of the participants included age, gender, academic year, place of birth, student cadre experience, volunteer activity experience, academic performance, family financial situation, physical fitness and psychological traits.

Digital health literacy

The College Students' Digital Health Literacy Scale, developed by Tang Zeng et al., is primarily used for assessing digital health literacy among college students [36]. The scale comprises 20 items, including three (3) dimensions: digital health acquisition ability, digital health appraisal ability, and digital health practice ability. All items are rated on a five (5) point scale ranging from 1 (completely inconsistent) to 5 (completely consistent). The total score for the scale ranges from 20 to 100, with higher scores indicating greater digital health literacy. The scale has good reliability and validity (the Cronbach's alpha coefficient of the scale was 0.915, the Cronbach's alpha coefficient of each dimension of the scale was between 0.836 and 0.895) [36]. In this study, Cronbach's alpha coefficient of the scale was 0.78.

Health lifestyles

The College Students' Healthy Lifestyle Assessment Scale was developed by Wang Dong and revised by Jiao Jianpeng [37, 38]. It consists of 33 items, organized into eight (8) dimensions: exercise behavior, regular lifestyle behavior, dietary nutrition behavior, health-hazard behavior, health-responsible behavior, social support behavior, stress management behavior, and life appreciation behavior. All items are rated on a five (5) point scale ranging from 1 (never) to 5 (always). Items 11 and 12 are reverse scored. The total score ranges from 33 to 165, with higher scores indicating a higher level of healthy lifestyle. The scale has good reliability and validity (the Cronbach's alpha coefficient of the scale was 0.898) [38]. In this study, Cronbach's alpha coefficient of the scale was 0.82.

Psychological resilience

The Psychological Resilience Scale, adapted and revised by Yu Xiaonan et al., is utilized to measure the

psychological resilience level of research subjects [39]. This scale includes three (3) dimensions: tenacity, self-improvement, and optimism, comprising a total of 25 items. All items are rated on a five (5) point scale ranging from 1 to 5. The total score ranges from 25 to 125, a higher score suggests a higher level of psychological resilience. The scale has good reliability and validity (the Cronbach's alpha coefficient of the scale was 0.91) [39]. In this study, Cronbach's alpha coefficient of the scale was 0.80.

Ethical consideration

The study protocols underwent review and approval by the university's Ethics Review Committee, the Ethics Review Number is 2023010. Students who voluntarily completed the survey were considered to have given implied informed consent. Privacy and confidentiality of the participants were diligently upheld. Participants were free to omit questions or cease participation at any point.

Data collection

The study conducted utilizing an online survey questionnaire between June and October 2023. Before the actual data collection, the survey underwent a reliability pre-test. This study was conducted using the Chinese online survey platform (Questionnaire Star). The survey links or QR codes were distributed to the study participants via WeChat groups by school contacts. After clicking the link or scanning the QR code, participants anonymously completed and submitted the questionnaire. Completing this questionnaire will take approximately 10 min. Each ID is allowed to submit only one questionnaire. The total number of undergraduate nursing students at the two surveyed nursing colleges are 770 and 620, respectively. This study recruited a total of 418 undergraduate nursing students. After excluding 11 students on leave, 407 students participated in questionnaire completion and submission. Following data cleaning, a total of 373 valid questionnaires were obtained, resulting in an effective response rate of 89.23% (373/418). The data collection procedure is shown in Fig. 1.

Statistical analysis

The data organization and analysis were conducted using IBM SPSS Statistics software, version 25. All tests were two-tailed, with a significance level set at $\alpha=0.05$. Continuous variables are presented as mean \pm standard deviation (SD), and categorical variables are described in terms of frequency (percentage composition). Descriptive Statistics: Initial analysis involved calculating descriptive statistics to summarize the sample's characteristics, including means, standard deviations, and frequencies. Assessment of Normality: We assessed the normality of the distribution of our continuous variables using the

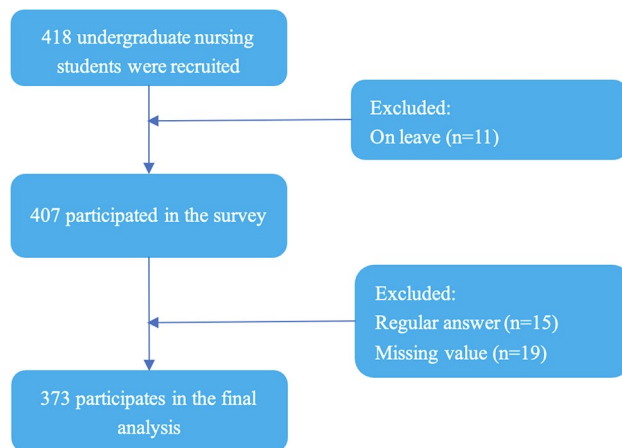


Fig. 1 The selection process of participants

Shapiro-Wilk test due to its robustness for larger sample sizes. Exploratory Data Analysis: We performed exploratory data analysis to identify any outliers or patterns in the data, which included visual tools such as box plots and histograms. Correlation Analysis: To evaluate the associations among digital health literacy, healthy lifestyles, and psychological resilience, we used Pearson correlation coefficients. We interpreted the strength of the correlation based on established criteria where an r value of 0.1 to 0.3 indicates a small effect, 0.3 to 0.5 a medium effect, and greater than 0.5 a large effect [40]. Multiple Linear Regression Analysis: To identify factors influencing digital health literacy, we employed multiple linear regression analysis. We reported the unstandardized (B) and standardized (β) regression coefficients, t -values, and p -values for each predictor variable. We also provided the model's F -statistic, overall significance, and R -squared value to indicate the proportion of variance explained by the model. Model Diagnostics: We conducted residual analysis to check for homoscedasticity and normality of residuals. We also assessed multicollinearity using Variance Inflation Factors (VIF), ensuring that all VIF values were below the threshold of 10, indicating no significant multicollinearity issues. Data Collection: Before the actual data collection, the survey underwent a reliability pre-test. The online survey platform (Questionnaire Star) was used for data collection, and the survey links or QR codes were distributed via WeChat groups. Data Cleaning: After data collection, we performed data cleaning to handle missing values, duplicates, and inconsistencies to ensure data quality.

Results

Socio-demographic characteristics and descriptive analysis

Descriptive statistics and differences in digital health literacy scores among undergraduate nursing students with various characteristics are presented in Table 1. The demographic characteristics of the participants are

detailed below. In terms of gender, 270 individuals, comprising 72.4% of the sample, identified as female. Regarding academic standing, the distribution of students across the first, second, third, and fourth years was as follows: 71 (19.0%), 144 (38.6%), 110 (29.5%), and 48 (12.9%), respectively. A majority of the students, 53.1%, hailed from township areas. Experience in student cadre roles was less common, with 60.1% of the participants reporting no such experience. In contrast, a significant proportion of the students, 78.6%, had engaged in volunteer activities. Regarding academic performance, an overwhelming majority, 97.0%, reported having achieved passing grades.

Key demographic factors such as gender, volunteer activity experience, academic performance, family financial situation, physical fitness and psychological traits showed significant differences in digital health literacy scores ($P < 0.05$).

Health lifestyles and psychological resilience

Table 2 presents the mean scores for health lifestyles and psychological resilience, which were 127.14 ± 11.22 and 79.21 ± 11.02 , respectively. The scores for each dimension of the health lifestyles, ranked from highest to lowest, are as follows: health-responsible behavior, social support behavior, health-hazard behavior, stress management, life appreciation behavior, dietary nutrition behavior, regular lifestyle behavior, exercise behavior. The scores for each dimension of the psychological resilience, ranked from highest to lowest, are as follows: self-improvement, optimism, tenacity.

Association between digital health literacy, health lifestyles and psychological resilience

Table 3 illustrates significant positive correlations between digital health literacy and two key domains: health lifestyles ($r = 0.707$, $P < 0.01$) and psychological resilience ($r = 0.638$, $P < 0.01$). These robust associations suggest a direct relationship, indicating that an enhancement in digital health literacy is paralleled by improvements in both health lifestyles and psychological resilience.

Regression analysis

In this study, we utilized a multiple linear regression model to explore the interrelationships between digital health literacy and an array of independent variables, encompassing gender, volunteer activity experience, academic performance, family financial situation, physical fitness, psychological traits, health lifestyles, and psychological resilience among undergraduate nursing students. Rigorous model diagnostics, comprising residual analysis and assessments for multicollinearity, confirmed that the model assumptions were not significantly violated,

Table 1 Characteristics of undergraduate nursing students according to digital health literacy (N=373)

Variables	Categories	Frequency	Percentage	Digital health literacy (mean ± SD)	t/F	P-value
Gender	Male	103	27.6	76.36 ± 7.69	2.239	0.026
	Female	270	72.4	74.18 ± 8.64		
Academic Year	First year	71	19.0	74.14 ± 7.97	0.702	0.551
	Second year	144	38.6	75.09 ± 8.33		
	Third year	110	29.5	75.34 ± 8.95		
	Fourth year	48	12.9	73.54 ± 8.29		
Place of Birth	Urban area	85	22.8	75.52 ± 8.44	0.435	0.648
	Township	198	53.1	74.63 ± 8.33		
	Rural area	90	24.1	74.42 ± 8.73		
Student Cadre Experience	None	224	60.1	74.44 ± 8.50	-0.956	0.340
	Yes	149	39.9	75.30 ± 8.35		
Volunteer Activity Experience	None	80	21.4	62.70 ± 4.32	21.767	0.000
	Yes	293	78.6	78.08 ± 5.90		
Academic Performance	Fail	26	7.0	64.92 ± 7.56	21.397	0.000
	Pass	155	41.5	74.16 ± 8.24		
	Good	135	36.2	75.39 ± 7.46		
	Excellent	57	15.3	79.54 ± 7.56		
Family Financial Situation	Poor	64	17.2	71.48 ± 8.62	11.591	0.000
	Moderate	194	52.0	74.29 ± 7.99		
	Good	115	30.8	77.45 ± 8.33		
Physical Fitness	Poor	43	11.5	66.56 ± 7.37	30.982	0.000
	Fair	204	54.7	74.87 ± 7.93		
	Good	126	33.8	77.44 ± 7.82		
Psychological Traits	Poor	42	11.3	70.81 ± 7.31	20.320	0.000
	Fair	173	46.4	73.01 ± 8.57		
	Good	158	42.3	77.78 ± 7.58		

Note: Volunteer Activity Experience refers to the experience of students participating in volunteer activities during their college years, such as community volunteers and kindergarten volunteers

Table 2 Score of digital health literacy, health lifestyles and psychological resilience (N=373)

Scale/dimension	The number of items	Min	Max	Average score of dimensions (mean ± SD)	Average score of items (mean ± SD)
HL-exercise behavior	3	5	12	9.04 ± 1.99	3.01 ± 0.66
HL-regular lifestyle behavior	3	7	14	10.66 ± 2.01	3.55 ± 0.67
HL-dietary nutrition behavior	4	11	18	14.66 ± 2.07	3.67 ± 0.51
HL- health-hazard behavior	2	5	12	8.15 ± 2.00	4.08 ± 1.00
HL-health-responsible behavior	5	15	25	20.61 ± 2.72	4.12 ± 0.54
HL-social support behavior	6	20	30	24.53 ± 3.03	4.09 ± 0.50
HL-stress management behavior	5	15	24	19.78 ± 2.81	3.96 ± 0.56
HL-life appreciation behavior	5	15	24	19.70 ± 2.59	3.94 ± 0.51
HL	33	99	151	127.14 ± 11.22	3.85 ± 0.34
PR-tenacity	13	24	51	37.86 ± 8.42	2.91 ± 0.64
PR-self-improvement	8	22	33	27.60 ± 3.42	3.45 ± 0.42
PR-optimism	4	10	17	13.75 ± 1.76	3.44 ± 0.44
PR	25	57	100	79.21 ± 11.02	3.17 ± 0.44

Note: HL: health lifestyles; PR: psychological resilience

thereby substantiating the reliability and validity of our regression findings.

The regression analysis disclosed that several factors significantly forecasted digital health literacy, including the presence of volunteer activity experience, superior academic performance (good and excellent), varied levels

of physical fitness (fair and good), psychological traits rated as fair, and elevated health lifestyles and psychological resilience ($F=58.091$, $P<0.001$, $R^2 = 0.678$, adjusted $R^2 = 0.666$). Specifically, excellent academic performance ($\beta=0.210$, $P<0.001$) and fair physical fitness ($\beta=0.278$,

Table 3 Correlation between digital health literacy, health lifestyle and psychological resilience ($N = 373$, r)

Variable	DHL-digital health acquisition ability	DHL-digital health practice ability	DHL-digital health appraisal ability	DHL
HL-exercise behavior	0.331**	0.348**	0.373**	0.469**
HL-regular lifestyle behavior	0.355**	0.360**	0.363**	0.478**
HL-dietary nutrition behavior	0.361**	0.341**	0.381**	0.483**
HL- health-hazard behavior	0.412**	0.387**	0.439**	0.553**
HL-health-responsible behavior	0.230**	0.272**	0.301**	0.358**
HL-social support behavior	0.152**	0.180**	0.202**	0.238**
HL-stress management behavior	0.412**	0.374**	0.395**	0.526**
HL-life appreciation behavior	0.232**	0.209**	0.211**	0.290**
HL	0.516**	0.515**	0.555**	0.707**
PR-tenacity	0.440**	0.376**	0.439**	0.562**
PR-self-improvement	0.347**	0.372**	0.428**	0.513**
PR-optimism	0.228**	0.222**	0.247**	0.311**
PR	0.480**	0.438**	0.508**	0.638**

Note: DHL: digital health literacy; HL: health lifestyles; PR: psychological resilience. ** $P < 0.01$ (two tailed)

$P = 0.002$) were the strongest predictors of higher digital health literacy (Table 4).

Discussion

The results of this study indicate that the score of digital health literacy is 74.78 ± 8.44 , suggesting that undergraduate nursing students have a moderate level of digital health literacy. Nursing undergraduates, being at a pivotal stage of improving physical health literacy and acquiring technological and cultural knowledge, are positioned to integrate these aspects effectively. The moderate digital health literacy level observed suggests a foundational proficiency in utilizing digital resources for health information, showcasing the evolving nature of healthcare towards digitalization. The study's alignment with Guo Mei'e et al.'s research and surpassing Wu Qiong et al.'s findings on digital health literacy among college students in China provides valuable context [41, 42]. The moderate digital health literacy level appears to be a consistent trend among Chinese nursing undergraduates, emphasizing the need for targeted interventions to further enhance their digital health literacy. The study highlights the critical developmental phase of undergraduate nursing students, emphasizing their foundational proficiency in digital health literacy and their potential to significantly contribute to the future nursing workforce. By assessing their current levels of digital health literacy and identifying areas for improvement, the study aims to inform educational strategies that will equip these students with the necessary skills to meet the evolving demands of healthcare delivery. The study anticipates that nursing students with higher levels of digital health literacy will play a significant role in advancing societal health literacy. Equipped with the ability to effectively navigate and critically appraise health information, these students are poised to become influential agents

of change within their communities and future workplaces [43]. They are expected to contribute to public health initiatives, educate patients on preventive measures, and employ digital tools to enhance health promotion strategies, thereby improving overall population health outcomes [44]. The expected benefit of this study lies in identifying the pivotal contributions that nursing students with elevated digital health literacy can make to society, highlighting the transformative impact of digital health literacy on traditional healthcare practices and community well-being. Despite the observed moderate level of digital health literacy, the study indicates room for improvement. This opens avenues for educational interventions and targeted training programs specifically designed for nursing students. Such programs can address identified gaps and ensure that nursing professionals are well-equipped to navigate the increasingly digital landscape of healthcare [45]. The study's findings align with the ongoing trends in healthcare towards digitalization. Recognizing the significance of digital health literacy, nursing education programs can adapt their curriculum to prepare students for the demands of a digitally-driven healthcare environment. This adaptability is essential for the effective integration of technology in nursing practice [46].

Our findings of a moderate level of digital health literacy among undergraduate nursing students are in line with those reported by Kim, who identified a significant association between digital health literacy and health behaviors, underscoring the impact of knowledge and beliefs on shaping health behaviors [41, 42]. The positive association we observed between digital health literacy and health lifestyles, as well as psychological resilience, echoes Kim's work, which highlights the role of eHealth literacy in promoting health-conscious actions and mental well-being among adults [47]. Higher digital health literacy among nursing students enables them to actively

Table 4 Linear regression analysis on digital health literacy

Variable	B	S.E.	β	t	p	95%CI		VIF
						Lower	Upper	
Constant	38.016	5.384	-	7.061	0.000	27.427	48.604	-
Gender								
Male	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Female	-0.204	0.288	-0.022	-0.706	0.480	-0.771	0.363	1.043
Volunteer Activity Experience								
Yes	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
None	-3.667	0.561	-0.357	-6.535	0.000	-4.771	-2.564	3.326
Academic Performance								
Fail	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Pass	1.011	0.540	0.118	1.870	0.062	-0.052	2.074	4.448
Good	1.127	0.365	0.193	3.091	0.002	0.410	1.844	4.329
Excellent	1.233	0.309	0.210	3.992	0.000	0.626	1.840	3.098
Family Financial Situation								
Poor	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Moderate	0.020	0.361	0.002	0.056	0.955	-0.689	0.730	2.038
Good	0.386	0.269	0.063	1.436	0.152	-0.143	0.914	2.171
Physical Fitness								
Poor	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Fair	2.356	0.490	0.278	4.812	0.000	1.393	3.319	3.724
Good	1.117	0.364	0.188	3.066	0.002	0.401	1.834	4.190
Psychological Traits								
Poor	Ref	Ref	Ref	Ref	Ref	Ref	Ref	Ref
Fair	-1.587	0.491	-0.188	-3.234	0.001	-2.552	-0.622	3.756
Good	-0.351	0.353	-0.062	-0.993	0.321	-1.045	0.344	4.296
Health Lifestyle	0.192	0.036	0.256	5.313	0.000	0.121	0.263	2.582
Psychological Resilience	0.116	0.034	0.152	3.414	0.001	0.049	0.183	2.199

Note: $F=58.091$, $P<0.001$, $R^2=0.678$, adjusted $R^2=0.666$. B: unstandardized regression coefficient; SE: standard errors; β : standardized regression coefficient; CI: confidence interval; VIF: Variance inflation factor

search for, discover, understand, and evaluate health information, leading to informed health decision-making [48]. Consequently, individuals with higher digital health literacy are more likely to improve their health behaviors and adopt healthier lifestyles. Furthermore, the positive correlation observed between digital health literacy and psychological resilience among undergraduate nursing students substantiates the role of digital skills in bolstering resilience. This relationship is supported by evidence that demonstrates an enhancement in resilience as a result of increased digital skills, which empowers individuals to navigate and manage the challenges they encounter more effectively [49, 50]. Recognizing this link can inform targeted interventions to bolster both digital health literacy and psychological resilience. The inverse relationship between lower digital health literacy and decreased psychological resilience not only suggests a vulnerability in dealing with stress but also indicates a deficiency in navigating the digital landscape, which is critical for accessing health resources and support. This vulnerability is particularly concerning given the reliance on digital platforms for health information and services. To address this, educational interventions should

be designed to enhance both digital health literacy and psychological resilience among nursing students. Such interventions could incorporate strategies that improve digital skills, foster self-efficacy with technology, and promote a proactive approach to online challenges, similar to the successful educational intervention reported by that improved elementary students' adaptive responses to digital threats [51].

Multiple linear regression results indicate that the presence of volunteer activity experience, superior academic performance (good and excellent), varied levels of physical fitness (fair and good), psychological traits rated as fair, and elevated health lifestyles and psychological resilience are influencing factors for digital health literacy among Chinese nursing undergraduates. The results indicate that nursing students with volunteer experience are more likely to possess higher levels of digital health literacy. This could be attributed to the fact that students engaged in volunteer services are more attuned to societal healthcare needs, leading them to actively seek medical knowledge through digital media [52]. This underscores the positive role of social engagement in nurturing the overall competence and digital health literacy of nursing

students. Nursing undergraduates demonstrating superior academic performance are found to possess elevated levels of digital health literacy, suggesting a correlation between academic excellence and the adept utilization of digital health resources [53]. To transcend general observations, we propose an innovative educational synthesis that integrates digital health literacy into the core curriculum. This approach emphasizes skill development in discerning credible health information, leveraging digital tools for evidence-based practice, and fostering a proactive learning culture that encourages students to engage with current health technologies and resources [54]. Such initiatives could include digital health modules, workshops on information literacy, and collaborative projects that simulate real-world healthcare scenarios, thereby preparing nursing students to navigate the digital aspects of modern patient care more effectively. The results show that nursing students with good physical fitness and high scores in healthy lifestyle practices tend to have higher digital health literacy. This implies that good physical health and lifestyle play a crucial role in cultivating the comprehensive competence and digital health literacy of nursing students [55]. Nursing schools can contribute to enhancing students' digital health literacy by promoting healthy lifestyles and physical exercise. Nursing students with higher levels of psychological resilience demonstrate higher digital health literacy. This suggests that psychological resilience is crucial for effectively coping with stress and challenges, leading to better utilization of digital health information [56]. Looking ahead, nursing schools should prioritize initiatives that bolster psychological resilience among students, not only through targeted training but also by offering a diverse array of activities. These activities might encompass stress management seminars, peer mentorship networks, mindfulness workshops, and practical mentorship programs designed to equip students with essential coping mechanisms for the rigors of clinical practice [57, 58]. Furthermore, strategic partnerships with community health organizations can provide students with invaluable real-world insights, exposing them to a variety of healthcare contexts and patient demographics, thereby enriching their resilience. By seamlessly blending these activities with academic curricula, nursing schools will cultivate a comprehensive and supportive learning environment. This approach will nurture in students the psychological fortitude needed to thrive in their future careers, ensuring they are well-prepared to navigate the complexities and challenges of the nursing profession.

Limitations and directions

We acknowledge several limitations in our study that may impact the interpretation of the results. The sample, although representative of two nursing colleges, may not

fully represent all nursing students due to potential self-selection bias. Additionally, the reliance on self-reported data could introduce recall bias, affecting the accuracy of the responses. The use of validated scales, while beneficial, may not account for all aspects of the complex constructs being measured, suggesting a need for ongoing refinement of these tools. The results of this study have practical implications for nursing education. With the identified moderate level of digital health literacy, there is a clear need for educational interventions that enhance students' ability to navigate digital health resources. This could involve integrating digital health literacy into the curriculum, providing workshops on effective online health information evaluation, and encouraging the use of digital tools for health promotion. Looking ahead, future research should aim to address the limitations identified in this study. This includes employing a more diverse and representative sample, utilizing objective measurement methods, and considering additional variables such as social support and individual differences. Moreover, longitudinal studies could provide insights into the development of digital health literacy, health lifestyles, and psychological resilience over time, offering a more comprehensive understanding of these dynamics.

Conclusions

The results of this study indicate that the digital health literacy of undergraduate nursing students in China is at a moderate level and requires further enhancement. Additionally, multiple linear regression results indicate that the presence of volunteer activity experience, superior academic performance (good and excellent), varied levels of physical fitness (fair and good), psychological traits rated as fair, and elevated health lifestyles and psychological resilience are influencing factors for digital health literacy among Chinese nursing undergraduates. Given the study's findings that undergraduate nursing students exhibit moderate levels of digital health literacy, future initiatives in nursing education should prioritize evidence-based strategies to enhance this skill. Specifically, interventions should target the significant predictors identified in our analysis, such as volunteer experience, academic performance, physical fitness, and psychological traits. Integrating these targeted approaches with a focus on health lifestyles and psychological resilience will be essential to foster a comprehensive development in nursing students, preparing them with the necessary competencies for the evolving healthcare sector. In conclusion, this study provides valuable insights into the complex relationships among digital health literacy, health lifestyles, and psychological resilience among undergraduate nursing students in China. The identified associations underscore the importance of considering digital health literacy as an integral component of

nursing education, with potential implications for both personal well-being and professional preparedness in the evolving landscape of healthcare.

Abbreviations

DHL	Digital Health Literacy
SD	Standard Deviation
VIF	Variance Inflation Factors
HL	Health Lifestyles
PR	Psychological Resilience
B	Unstandardized regression coefficient
SE	Standard Errors
β	Standardized regression coefficient
CI	Confidence Interval

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Author contributions

LFL and QL conceived the study design. JJW, HYW, and JC developed the sampling strategy. MXF, JRJ, PC, LL and WZ performed data analyses. LFL and QL drafted the manuscript. All authors contributed to the preparation of the final version of the manuscript.

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Data availability

All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethics Committee of Sichuan Nursing Vocational College (2023010). All methods were carried out in accordance with the Declaration of Helsinki. Informed consent was obtained from all participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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