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The mediating role of depressive symptoms in the relationship between health literacy and suicide-related behaviors in middle school students

Ronghuinan Zhang[1,2], Aini Liu[1,2], Yu Luo[1,2], Chang Peng[1,2]✉ & Hong Wang[1,2]✉

Suicide-related behaviors among adolescents have garnered increasing social attention, while few studies have revealed the association between health literacy and suicide-related behaviors, and the underlying mechanism. Thus, this study aims to explore the effect of health literacy on suicide-related behaviors in Chinese adolescents, as well as the potential mediating role of depressive symptoms. A cross-sectional, questionnaire-based study was conducted among 7182 students who were selected by using stratified cluster sampling in May 2023. The Adolescent Health Literacy Scale, Center for Epidemiologic Studies Depression Scale, and three questions about the suicide-related behaviors were used to collect data. Chi-square tests were performed to compare the differences in the distribution of suicide-related behaviors across health literacy levels as well as sociodemographic characteristics. Spearman correlation analysis was performed to assess the correlations between variables. Bootstrap methods were performed to test the mediating role of depressive symptoms. The results showed that the prevalence of suicidal ideation, planning, and attempts in the past 12 months among Chinese middle school students was 26.62%, 9.27%, and 4.55%, respectively. Inadequate health literacy levels exhibited significant and positive correlation with depressive symptoms, suicidal ideation, planning, and attempts. Additionally, depressive symptoms were correlated significantly and positively with three suicide-related behaviors. Mediation analysis showed that the relationship between health literacy and suicide attempts was fully mediated by depressive symptoms and the mediation proportion was 64.9%, while depressive symptoms partially mediated the relationship between health literacy and suicidal ideation and planning, with the mediation proportion was 78.4% and 70.0%, respectively. By shedding light on these mechanisms, comprehensive health literacy improvement programs may be promising in preventing depression and suicide-related behaviors among adolescents.

Keywords Health literacy, Depression, Suicide-related behaviors, Mediation analysis, Middle school students

Abbreviations

HL	Health literacy
FHL	Functional health literacy
IHL	Interactive health literacy
CHL	Critical health literacy
SAMS	The schematic appraisal model of suicide
AHLS	The Adolescent Health Literacy Scale
CES-D	The Center for Epidemiologic Studies Depression Scale
KAP	The knowledge, attitude and practices model
Rel F	Relationship with father
Rel M	Relationship with mother

[1]College of Public Health, Chongqing Medical University, No. 61, University Town Middle Road, Huxi Street, Shapingba District, Chongqing 401331, China. [2]Research Center for Medicine and Social Development, Chongqing Medical University, Chongqing 401331, China. ✉email: pengchang333@cqmu.edu.cn; 100113@cqmu.edu.cn

Rel P	Relationship between parents
AP	Academic pressure
Rel T	Relationship with teachers
Rel C	Relationship with classmates
Dep	Depressive symptoms
SI	Suicidal ideation
SP	Suicide planning
SA	Suicide attempts

Suicide is a complex, influenced by multiple threatening factors behavior in which an individual automatically ends his or her life[1]. Academics generally categorize suicide-related behaviors as suicidal ideation, suicide planning and suicide attempts[2], and the occurrence of any one or more of these behaviors may develop into suicide[3]. Relevant statistics have shown that suicide is the second leading cause of death among young people at the global level[4]; more than seven percent of youth attempt suicide every year in the United States[5]. Therefore, it is important to pay attention to the problem of youth suicide. Studies have shown that the risk of suicide in the adolescent population increases from the age of 10 and reaches its peak at the age of 20–24[6]. This may be because younger children are not yet able to form mature thoughts about death, but when they enter adolescence, an unstable stage of physiological and psychological development and their ability to cope with negative life events is inadequate[7], so they are susceptible to psychological problems, which may lead to feelings of despair or suicidal ideation become apparent[8]. Freuchen et al. found that more than half of the children who committed suicide had shown suicide-related behaviors prior to suicide[9]. In addition, suicide-related behaviors are characterized by recurrence, suddenness and outbreaks[10], so may not be easily detected in time. However, the loss of life caused by the completion of a suicide can place a serious burden on the individual, family, society, and medical rescue system. Therefore, further exploration of the factors influencing suicide-related behaviors in adolescents is necessary.

The concept of health literacy (HL) was first proposed by the American scholar Simonds in 1974[11], after which the WHO defined HL as representing the cognitive and social skills of individuals who determine their motivation and ability to access, understand and process information or services, and through these means to make sound decisions to promote and maintain their health[12]. From the public health perspective, Prof. Nutbeam categorized health literacy into three levels based on its developmental stages: functional health literacy, interactive health literacy and critical health literacy, such classification has the benefit of emphasizing the impact of skill level differences on health-related decisions and actions, while also enabling a clear differentiation between task-based and skills-based interventions[13]. Functional health literacy is the most basic health literacy competency, which refers to the ability of individuals to access health information and apply it to their daily lives (e.g., health influencing factors, how to utilize the health system, etc.); interactive health literacy is a more advanced literacy competency, which refers to the ability of individuals to proactively extract and comprehend health information from different forms of communication media and apply it to their changing life situations as well as interact and exchange information with others to further expand information and make decisions; critical health literacy is the most advanced literacy competency, which means that individuals are able to critically analyze different sources of health information and knowledge, identify the authenticity of the information, and flexibly apply the correct information to different contexts in order to safeguard their own health[13]. The schematic appraisal model of suicide (SAMS) has stated that negative information processing bias, the appraisal system and the suicide schema interact to produce defeatism and entrapment, leading to suicidal behavior[14]. Breton et al. found that nonproductive coping strategies could foster suicidal ideation among adolescents[15]. A meta-analysis results also supported deficit in problem-solving skills was one of the key psychological traits associated with suicidal behavior[16]. The level of health literacy largely reflects an individual's coping style and problem-solving ability in the face of negative events. Related studies observed that college students with high levels of health literacy were more inclined to adopt positive coping styles and thus indirectly improve their lifestyles[17]. Xing et al. found that among occupational populations, mental health literacy level was positively correlated with positive coping strategies and negatively correlated with negative coping strategies[18]. Therefore, it has been found to be a direct or indirect predictor of suicide-related behaviors. For example, positive coping styles such as problem solving and support-seeking were negatively associated with suicidal ideation among middle school students[19]; adequate levels of health literacy were a protective factor for suicide-related outcomes among middle school girls[20]. Hom et al. also found that adolescents with inadequate health literacy are often unaware of the problems affecting their behavior and are unable to seek help before engaging in suicidal behaviors[21]. However, most existing studies focuses on the relationship between health literacy and general mental health problems, such as anxiety[22], depression[23], obsessive–compulsive disorder[24], and social anxiety[25], and the researches on factors influencing suicide-related behaviors have primarily focused on negative life events[26], and psycho-behavioral problems[27], etc. There are relatively few current studies on the direct role of health literacy on suicide-related behaviors among adolescents. Consequently, exploring the correlation between adolescents' health literacy levels and suicide-related behaviors is valuable.

Carballo et al. reviewed the effects of psychosocial risk factors on suicide-related behaviors and noted that psychological problems are an important cause of suicide among children, with depression being the most important cause[28]. Depression is characterized by low mood, decreased energy, sleep and appetite disturbances, feelings of guilt and/or low self-worth, poor concentration and irritability[29]. At present, depression is highly prevalent in adolescents, and the trend is rising across the world[30]. Studies have systematically illustrated that depressive symptoms involve a higher risk of negative outcomes, such as psychiatric comorbidity[31], self-harm[32], substance abuse[33], and other health risk behaviors[34]. At the same time, studies in adolescent populations have also found that depressive symptoms are a risk factor for suicidal ideation[35,36], suicide planning[37] and suicide

attempts[38]. Roberto et al. found that depressive symptoms predicted the severity of suicidal ideation three months later[39]. In addition, the research suggests that when depressive symptoms become severe, adolescents are likely to resort to more extreme forms of avoidance to end their suffering, at which point suicide is often considered one of the most severe forms of avoidance[40].

Some studies have revealed that adequate levels of health literacy are an important factor in promoting mental health, especially in preventing and protecting against depressive symptoms. For example, Lam et al. found that mental health literacy was significantly associated with depressive symptoms[41]; Guo et al. discovered that health literacy levels were significantly associated with the risk of depressive symptoms one year later in adolescents based on a cohort study[20]. On the other hand, depressive symptoms are frequently correlated with suicide-related outcomes[42]. Therefore, individuals with inadequate health literacy are more likely to experience negative emotions when exposed to adverse stimuli[43], but are also limited by insufficient health knowledge and problem-solving skills, and tend to focus more on the negative emotions themselves rather than effectively addressing the underlying issues resulting in further exacerbation of emotional distress, which may even lead to suicide-related behaviors[27]. Prior research has found that depressive symptoms mediate the negative effect of shyness[44] and childhood maltreatment[45] on suicide-related behaviors. As such, we hypothesized that depressive symptoms may also mediate the association between health literacy and suicide-related behaviors.

In conclusion, the above studies suggest that health literacy is associated with suicide-related behaviors and that depressive symptoms may play a mediating role in the relationship. However, there is little research on the direct relationship and mechanisms between general health literacy and suicide-related behaviors and a relative lack of research with middle school students. Therefore, in the present study, we investigated the relationship between general health literacy and suicide-related behaviors and the mediating role of depressive symptoms between the two, controlling for relevant confounders, in a large sample of Chinese middle school students.

Methods

Study population

In this cross-sectional study, we adopted a stratified cluster sampling method to select the study sample. In the first stage, based on the level of regional economic development, three districts and counties representing good, medium and poor levels were selected separately from Chongqing, China. In the second stage, two urban middle schools and two rural middle schools were selected from each district; given that rural schools generally have smaller student enrollments than urban schools, we selected two medium-sized schools from urban areas and two from rural areas in each district, resulting in a total of 12 schools included in the study. In the third stage, four classes were then randomly chosen for each grade from grade 7 to 9 in the twelve selected schools. This study was a school-based survey. We used paper questionnaires to collect data from students in May 2023. The questionnaire took approximately 15 to 20 min to complete. The inclusion criterion was that students who were in school at the time and could understand and complete the questionnaire independently. At the time of the formal survey, uniformly trained investigators explained the purpose and significance of the survey to the students surveyed, informed them of their right to refuse to participate in the survey, and promised that all data collected would be kept strictly confidential and would be used only for the purposes of this study, and that the data would be stored in password-protected, encrypted files to which only members of the research team would be authorized to have access. At the same time, during the data collection process, all survey respondents remained anonymous and no information was collected that could directly identify individuals. All 12 selected schools according to the original plan agreed to participate in the survey, and according to the total number of students enrolled in the sampled classes provided by the schools, 7,783 questionnaires were distributed, and 7,491 questionnaires were collected due to the absence of students on leave and the refusal of some students to answer, etc., resulting in a response rate of 96.2%. Questionnaires with incorrect or missing data (absence rate $\geq 20\%$) were excluded. Finally, a total of 7491 questionnaires were collected, and 7182 were valid, yielding an effective response rate of 95.9%. The study was approved by the ethical committee of Chongqing Medical University in accordance with the Declaration of Helsinki and obtained the consent of the subjects and guardians.

Measures

Sociodemographic characteristics

According to published literature[46–48], family and school climate, academic stress, etc. may be influential factors in adolescent suicide-related behaviors, so a self-administered basic information questionnaire was designed to collect the following information: area (urban/rural), gender (male/female), grade (grades 7 to 9), relationship with father (three options), relationship with mother (three options), relationship between parents (three options), relationship with teachers (three options), relationship with classmates (three options) and academic pressure (three options). The three options for the above six variables were good, moderate and poor, except for academic stress, which was high, moderate and low. The six items (relationship with father, relationship with mother, relationship between parents, relationship with teachers, relationship with classmates and academic pressure) needed participants to select the most appropriate one based on their subjective feelings without repeated reflection, using the status of their classmates as a reference.

Health literacy

The Adolescent Health Literacy Scale (AHLS) was used to assess health literacy levels[49]. It includes 12 factors in 3 dimensions, namely, functional health literacy (37 items), interactive health literacy (14 items) and critical health literacy (10 items). The 61 items are rated on five-point Likert scoring (strongly disagree, disagree, unsure, agree and strongly agree; or completely inconsistent, inconsistent, unclear, consistent and completely consistent), and the test scores range from a minimum of 61 points to a maximum of 305 points. Scores greater than or equal to 80% of the total score on the scale are considered adequate health literacy; otherwise, they are inadequate[50], and

the cut-off value in this study was 244. The AHLS scale has good reliability and validity in previous research[51]. The Cronbach's α coefficient of the total scale in this study was 0.970; the Cronbach's α coefficients for the three dimensions were 0.968, 0.902 and 0.921, respectively.

Depressive symptoms

Depressive symptoms were evaluated by the Center for Epidemiologic Studies Depression Scale (CES-D)[52]. The CES-D measures 4 factors: depressed mood, positive mood, somatic symptoms and relationship difficulties. It consists of 20 items with four answers for each item, as follows: rarely (< 1 day/week); some days (1–2 days/week); occasionally (3–4 days/week) and most (5–7 days/week)." For the negative items, the score was assigned 0, 1, 2, and 3 points for "rarely," "some days," "occasionally," and "most,", respectively, whereas for the positive items, the score was defined as 3, 2, 1, and 0 points for "rarely," "some days," "occasionally," and "most,", respectively. The total score was summed for the 20 items, ranging from 0 to 60, and a higher score indicates more severe subclinical depressive symptoms. Many studies have evaluated the diagnostic accuracy of the CES-D for detecting depressive symptoms in the general population and have proposed a variety of cut-off scores, a meta-analysis that included 28 CES-D studies recommended an optimal cut-off score of 20 with better trade-offs between sensitivity and specificity[53], therefore, the present study adopted a cutoff score of ≥ 20 to identify individuals with depressive symptoms. Previous studies have demonstrated the applicability of the scale in Chinese adolescent populations[54]. The Cronbach's α coefficient of the CES-D in this study was 0.876.

Suicide-related behaviors

Suicidal ideation, suicide planning, and suicide attempts of the study participants in the past 1 year were assessed through 3 questions: "Have you ever had suicidal thoughts and considered the matter of suicide?"; "Have you ever made a plan to end your life?"; "Have you ever attempted suicide?". Each question was answered using a binary response format (Yes or No). A "yes" answer means that the person has engaged in suicide-related behaviors[55].

Statistical analyses

Data were analysed using SPSS 26.0 and Mplus 8.3. Frequencies (proportion) for categorical variables and means (standard deviation, SD) for continuous variables were used to describe the essential characteristics of the participants. Chi-square tests were used to examine differences in categorical variables between the groups with and without the suicide-related behaviors. Spearman correlation analysis was performed to explore the correlations between variables. Bootstrap methods were performed to test the hypothesized mediating model, shown in Fig. 1. In all models, all paths were adjusted by area, gender, grade, relationship with father, relationship with mother, relationship between parents, relationship with teachers, relationship with classmates and academic pressure. 5000 bootstrap samples were performed to infer the significance of indirect effects, the size of the mediating effect was quantified as the ratio of the indirect effect to the total effect. All statistical tests were two-sided, and statistical significance was set at $\alpha = 0.05$.

Results

Demographic characteristics of the study population

The general demographic characteristics of the study participants are presented in Table 1. The average age of the subjects was 13.83 (0.96) years, with 49.64% male and 50.36% female students. Among the 7182 students surveyed, the prevalence of suicidal ideation, planning and attempts in the past 12 months was 26.62%, 9.27%, and 4.55%, respectively. The results of the chi-square test showed that the prevalence of suicidal ideation, planning and attempts were higher in female students than in male students (all $P < 0.001$), but no significant difference was found between urban and rural students for the three suicide-related behaviors. Besides, the grade level of attendance, relationships with father and mother, relationship between parents, academic stress, and relationship with teachers and classmates were the influencing factors for suicidal ideation, planning, and attempts (all $P < 0.05$), except for suicidal attempts, for which no significant difference was found between different grades.

The correlations among health literacy, depressive symptoms and suicide-related behaviors

The correlations among all variables are presented in Table 2. The results showed that inadequate health literacy levels were significantly and positively associated with depressive symptoms ($\rho = 0.247$, $P < 0.001$), suicidal ideation ($\rho = 0.179$, $P < 0.001$), suicide planning ($\rho = 0.152$, $P < 0.001$), and suicide attempts ($\rho = 0.124$, $P < 0.001$), i.e., inadequate health literacy was a risk factor for the incidence of depressive symptoms and suicide-related behaviors. After dividing health literacy into three dimensions, the results were similar to the total health literacy. Inadequate functional health literacy levels were significantly and positively associated with depressive symptoms ($\rho = 0.174$, $P < 0.001$), suicidal ideation ($\rho = 0.128$, $P < 0.001$), suicide planning ($\rho = 0.115$, $P < 0.001$), and suicide attempts ($\rho = 0.087$, $P < 0.001$). Inadequate interactive health literacy levels were significantly and positively associated with depressive symptoms ($\rho = 0.309$, $P < 0.001$), suicidal ideation ($\rho = 0.227$, $P < 0.001$), suicide planning ($\rho = 0.172$, $P < 0.001$), and suicide attempts ($\rho = 0.123$, $P < 0.001$). Inadequate critical health literacy levels were significantly and positively associated with depressive symptoms ($\rho = 0.149$, $P < 0.001$), suicidal ideation ($\rho = 0.124$, $P < 0.001$), suicide planning ($\rho = 0.098$, $P < 0.001$), and suicide attempts ($\rho = 0.075$, $P < 0.001$). Depressive symptoms were significantly and positively correlated with suicidal ideation ($\rho = 0.459$, $P < 0.001$), suicide planning ($\rho = 0.344$, $P < 0.001$), and suicide attempts ($\rho = 0.250$, $P < 0.001$), suggesting that depressive symptoms could increase the incidence of suicide-related behaviors. In addition, suicidal ideation, suicide planning, and suicide attempts were significantly and positively relevant ($\rho = 0.329$—0.503, all $P < 0.001$),

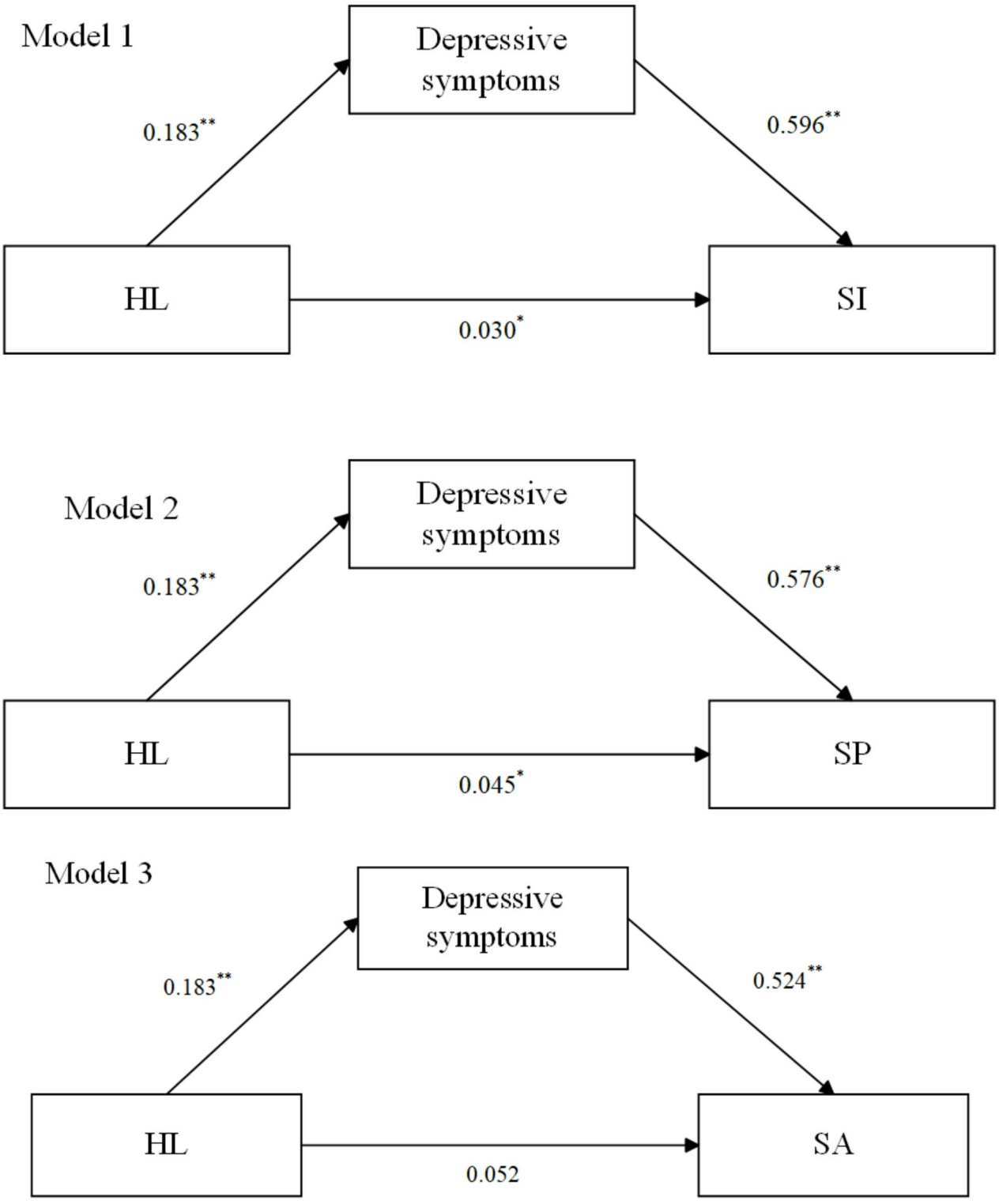

Fig. 1. Path model testing the mediation effect of depressive in the association between HL and SI, SP, SA. Abbreviations: HL, health literacy. SI, suicidal ideation. SP, suicide planning. SA, suicide attempts. $^{*}P < 0.05$. $^{**}P < 0.01$.

Variables	N	Suicidal ideation			Suicide planning			Suicide attempts		
		n	%	X^2	n	%	χ^2	n	%	χ^2
Area				1.592			0.593			0.728
Urban	3833	1044	27.24		346	9.03		167	4.36	
Rural	3349	868	25.92		320	9.56		160	4.78	
Gender				178.312**			47.370**			40.648**
Male	3565	699	19.61		246	6.9		106	2.97	
Female	3617	1213	33.54		420	11.61		221	6.11	
Grade				16.574**			14.547*			1.788
7th	2414	677	28.04		245	10.15		116	4.81	
8th	2372	669	28.2		243	10.24		113	4.76	
9th	2396	566	23.62		178	7.43		98	4.09	
Relationship with father				403.001**			354.781**			226.313**
Good	5341	1118	20.93		317	5.94		141	2.64	
Moderate	1494	588	39.36		240	16.06		126	8.43	
Poor	347	206	59.37		109	30.55		60	17.29	
Relationship with mother				285.618**			214.999**			158.861**
Good	5773	1292	22.38		395	6.84		182	3.15	
Moderate	1151	482	41.88		210	18.25		103	8.95	
Poor	258	138	53.49		61	23.64		42	16.28	
Relationship between parents				239.441**			192.435**			139.373**
Good	5463	1212	22.19		367	6.72		161	2.95	
Moderate	1337	521	38.97		213	15.93		122	9.12	
Poor	382	179	46.86		86	22.51		44	11.52	
Academic pressure				410.239**			188.433**			88.771**
High	2906	1144	39.37		435	14.97		214	7.36	
Moderate	3644	676	18.55		200	5.49		97	2.66	
Low	632	92	14.56		31	4.91		16	2.53	
Relationship with teachers				187.355**			116.608**			86.086**
Good	4092	850	20.77		268	6.55		118	2.88	
Moderate	2898	969	33.44		351	12.11		182	6.28	
Poor	192	93	48.44		47	24.48		27	14.06	
Relationship with classmates				240.588**			235.975**			177.746**
Good	5491	1233	22.45		372	6.77		170	3.1	
Moderate	1537	587	38.19		240	15.61		123	8	
Poor	154	92	59.74		54	35.06		34	22.08	
HL										
Adequate	4516	928	20.55	229.684**	266	5.89	165.494**	116	2.57	110.239**
Inadequate	2666	984	36.91		400	15.00		211	7.91	
FHL										
Adequate	4783	1081	22.60	118.529**	331	6.92	94.218**	156	3.26	54.959**
Inadequate	2399	831	34.64		335	13.96		171	7.13	
IHL										
Adequate	3923	686	17.49	368.348**	185	4.72	213.427**	87	2.22	108.498**
Inadequate	3259	1226	38.85		481	14.76		240	7.36	
CHL										
Adequate	5221	1215	23.27	109.897**	393	7.53	69.277**	188	3.60	39.895**
Inadequate	1961	697	35.54		273	13.92		139	7.09	
Dep										
No	4976	652	13.10	1515.708**	131	2.63	849.109**	54	1.09	448.305**
Yes	**2206**	1260	57.12		535	24.25		273	12.38	

Table 1. Comparison of suicide-related behaviors across basic characteristics. HL, health literacy. FHL, functional health literacy. IHL, interactive health literacy. CHL, critical health literacy. Dep, depressive symptoms. $^{*}P<0.01$; $^{**}P<0.001$.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1.Area	1																
2.Gender	− 0.016	1															
3.Grade	0.046***	− 0.004	1														
4.Rel F	0.003	0.035**	0.029*	1													
5.Rel M	0.060***	− 0.003	0.013	0.539***	1												
6.Rel P	0.043***	0.034**	0.002	0.529***	0.528***	1											
7.AP	0.037**	− 0.090***	− 0.040**	− 0.088***	− 0.066***	− 0.050***	1										
8.Rel T	0.089***	0.064***	0.030*	0.276***	0.241***	0.221***	− 0.066***	1									
9.Rel C	0.050***	0.073***	0.005	0.226***	0.211***	0.203***	− 0.059***	0.436***	1								
10.HL	0.139***	0.022	0.077***	0.195***	0.184***	0.175***	− 0.062***	0.244***	0.196***	1							
11.FHL	0.148***	0.011	0.062***	0.165***	0.164***	0.147***	− 0.032**	0.217***	0.170***	0.745***	1						
12.IHL	0.088***	0.049***	0.054***	0.200***	0.183***	0.173***	− 0.127***	0.248***	0.191***	0.647***	0.435***	1					
13.CHL	0.102***	0.010	0.011	0.122***	0.101***	0.105***	− 0.039**	0.170***	0.125***	0.536***	0.376***	0.437***	1				
14.Dep	0.043***	0.133***	0.026*	0.245***	0.225***	0.182***	− 0.270***	0.232***	0.254***	0.247***	0.174***	0.309***	0.149***	1			
15.SI	− 0.015	0.158***	− 0.041**	0.228***	0.197***	0.161***	− 0.233***	0.158***	0.175***	0.179***	0.128***	0.227***	0.124***	0.459***	1		
16.SP	0.009	0.081***	− 0.038**	0.207***	0.172***	0.139***	− 0.155***	0.116***	0.162***	0.152***	0.115***	0.172***	0.098***	0.344***	0.503***	1	
17.SA	0.010	0.075***	− 0.014	0.165***	0.141***	0.203***	− 0.106***	0.099***	0.133***	0.124***	0.087***	0.123***	0.075***	0.250***	0.329***	0.499***	1

Table 2. Spearman's correlation coefficients between all variables. Rel F, Relationship with father. Rel M, Relationship with mother. Rel P, Relationship between parents. AP, Academic pressure. Rel T, Relationship with teachers. Rel C, Relationship with classmates. HL, health literacy. FHL, functional health literacy. IHL, interactive health literacy. CHL, critical health literacy. Dep, depressive symptoms. SI, suicidal ideation. SP, suicide planning. SA, suicide attempts. $^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$.

Pathway	Suicidal ideation				Suicide planning				Suicide attempts			
	Estimate	*SE*	*95%CI*	*P*	Estimate	*SE*	*95%CI*	*P*	Estimate	*SE*	*95%CI*	*P*
HL → SI/SP/SA(c′)	0.030	0.015	(0.001,0.059)	0.040	0.045	0.020	(0.005,0.085)	0.029	0.052	0.027	(0.000,0.105)	0.051
HL → Dep(a)	0.183	0.014	(0.156,0.210)	< 0.001	0.183	0.014	(0.156,0.210)	< 0.001	0.183	0.014	(0.156,0.210)	< 0.001
Dep → SI/SP/SA(b)	0.596	0.019	(0.559,0.634)	< 0.001	0.576	0.026	(0.525,0.628)	< 0.001	0.524	0.037	(0.451,0.596)	< 0.001
HL → Dep → SI/SP/SA(a*b)	0.109	0.009	(0.091,0.127)	< 0.001	0.105	0.009	(0.087,0.123)	< 0.001	0.096	0.010	(0.076,0.115)	< 0.001
a*b/(a*b + c′)	0.784				0.700				0.649			
FHL → SI/SP/SA(c1′)	0.024	0.015	(-0.004,0.053)	0.098	0.036	0.020	(-0.003,0.075)	0.071	0.027	0.026	(-0.023,0.077)	0.294
FHL → Dep(a1)	0.109	0.014	(0.082,0.137)	< 0.001	0.109	0.014	(0.082,0.137)	< 0.001	0.109	0.014	(0.082,0.137)	< 0.001
Dep → SI/SP/SA(b1)	0.601	0.019	(0.565,0.637)	< 0.001	0.582	0.026	(0.532,0.633)	< 0.001	0.532	0.036	(0.462,0.602)	< 0.001
FHL → Dep → SI/SP/SA(a1*b1)	0.066	0.009	(0.048,0.083)	< 0.001	0.064	0.009	(0.047,0.081)	< 0.001	0.058	0.009	(0.041,0.075)	< 0.001
a1*b1/(a1*b1 + c1′)	0.733				0.640				0.682			
IHL → SI/SP/SA(c2′)	0.039	0.016	(0.008,0.070)	0.013	0.046	0.022	(0.004,0.089)	0.033	0.023	0.028	(-0.032,0.079)	0.413
IHL → Dep(a2)	0.248	0.014	(0.221,0.275)	< 0.001	0.248	0.014	(0.221,0.275)	< 0.001	0.248	0.014	(0.221,0.275)	< 0.001
Dep → SI/SP/SA(b2)	0.590	0.020	(0.552,0.629)	< 0.001	0.570	0.027	(0.517,0.623)	< 0.001	0.526	0.038	(0.452,0.600)	< 0.001
IHL → Dep → SI/SP/SA(a2*b2)	0.146	0.009	(0.128,0.165)	< 0.001	0.141	0.010	(0.121,0.161)	< 0.001	0.131	0.012	(0.107,0.154)	< 0.001
a2*b2/(a2*b2 + c2′)	0.789				0.754				0.851			
CHL → SI/SP/SA(c3′)	0.033	0.014	(0.006,0.061)	0.018	0.028	0.019	(-0.009,0.065)	0.137	0.020	0.024	(-0.027,0.066)	0.403
CHL → Dep(a3)	0.101	0.014	(0.074,0.129)	< 0.001	0.101	0.014	(0.074,0.129)	< 0.001	0.101	0.014	(0.074,0.129)	< 0.001
Dep → SI/SP/SA(b3)	0.600	0.018	(0.564,0.636)	< 0.001	0.583	0.026	(0.533,0.633)	< 0.001	0.534	0.036	(0.464,0.604)	< 0.001
CHL → Dep → SI/SP/SA(a3*b3)	0.061	0.009	(0.044,0.078)	< 0.001	0.059	0.008	(0.043,0.076)	< 0.001	0.054	0.008	(0.038,0.070)	< 0.001
a3*b3/(a3*b3 + c3′)	0.649				0.678				0.730			

Table 3. The mediating effect of depressive symptoms on the relationship between health literacy and suicide-related behaviors. HL, health literacy. FHL, functional health literacy. IHL, interactive health literacy. CHL, critical health literacy. Dep, depressive symptoms, SI, suicidal ideation. SP, suicide planning. SA, suicide attempts.

indicating that the presence of any one of the suicide-related behaviors increases the risk of the other two behaviors as well.

The mediating role of depressive symptoms between health literacy and suicide-related behaviors

Figure 1 and Table 3 show the results of the hypothetical mediation model. All models were saturated models with $\chi^2 = 0.000$, $df = 0$, CFI = 1.000, TLI = 1.000, RMSEA = 0.000, SRMR = 0.000. The mediating role of depressive symptoms in the relationship between health literacy and suicidal ideation, suicide planning, and suicide attempts was statistically significant. The direct effects (c′) from health literacy to suicidal ideation, suicide planning, suicide attempts were 0.030 (95% CI 0.001–0.059), 0.045 (95% CI 0.005–0.085) and 0.052 (95% CI 0.000–0.105), respectively. The indirect effects of depressive symptoms (a*b) for suicidal ideation, suicide planning and suicide attempts were 0.109 (95% CI 0.091–0.127), 0.105 (95% CI 0.087–0.123) and 0.096 (95% CI 0.076, 0.115), respectively. The mediating effect sizes of depressive symptoms on suicidal ideation, suicide planning, and suicide attempts were 78.4%, 70.0%, and 64.9%, respectively. Furthermore, depressive symptoms fully mediated the relationship between health literacy and suicide attempts but partially mediated the relationships between health literacy and suicidal ideation and suicide planning.

After dividing health literacy into three dimensions, all models were saturated models, the mediation of depressive symptoms in the relationships between different dimensions of health literacy and the three suicide-related behaviors was also significant. The mediating effect sizes of depressive symptoms between functional health literacy and suicidal ideation, suicide planning, suicide attempts were 73.3%, 64.0% and 68.2%, respectively. The mediating effect sizes of depressive symptoms between interactive health literacy and suicidal ideation, suicide planning, suicide attempts were 78.9%, 75.4% and 85.1%, respectively. The mediating effect sizes of depressive symptoms between critical health literacy and suicidal ideation, suicide planning, suicide attempts were 64.9%, 67.8% and 73.0%, respectively (Table 3).

Discussion

To our knowledge, this is the first study to explore the effect of general health literacy on suicide-related behaviors in Chinese adolescents, as well as the potential mediating role of depressive symptoms. We have the following main findings: (1) the prevalence of suicidal ideation, planning, and attempts in the past 12 months among middle school students was 26.62%, 9.27%, and 4.55%, respectively, and suicidal ideation, planning, and attempts were pairwise correlated; (2) inadequate levels of health literacy and depressive symptoms were risk factors for the occurrence of suicide-related behaviors; and (3) depressive symptoms partially or fully mediated the relationship between health literacy and three suicide-related behaviors. These new findings highlight the potential of health literacy improvement programs to prevent depression and suicide-related behaviors in adolescents.

The prevalence rates of suicidal ideation, planning, and attempts among middle school students in this study were 26.62%, 9.27% and 4.55%, respectively, with suicidal ideation and attempts increasing relative to the results of a survey on suicide-related behaviors among middle school students in Chongqing City in 2019 (23.90% and 2.68%, respectively)[56], and the prevalence rates of suicidal ideation, planning, and attempts from this survey were higher than those from a meta-analysis of suicidal ideation, planning, and attempts that included findings published in 2010–2020 about suicide-related behaviors among Chinese adolescents (15.6%, 6.7%, and 3.4%, respectively)[57] but lower than a survey study during 2020–2021 (31.3%, 16.3% and 7.5%, respectively)[58]. A possible reason for the discrepant results between studies could be differences in the timing of the surveys. The current survey was conducted in the period when China had just gone through the phase of policy adjustments after three years of closed outbreak management, and although suicide-related behaviors were detected at a lower rate than during the epidemic, middle school students had not been fully adjusted in their learning and life, and some of the negative retardation effects caused by stress of uncertainty, social isolation, academic stress and lack of physical exercise during the epidemic, such as rising levels of depression and anxiety[59] and increased non-suicidal self-harm[60], are not fully eliminated, all of which are likely to increase the incidence of suicidal-related behavior[61,62]. Maciá-Casas found that among adolescents under the age of 18 who received psychological services in the emergency department, the post-pandemic detection rate of suicidal ideation was approximately twice that of the pre-pandemic period, and self-injurious behaviors were approximately 1.5 times the pre-pandemic rate[63]. A longitudinal study conducted among Chinese adolescents revealed that although psychological symptoms such as anxiety, depression, academic stress, and suicidal ideation exhibited a recovery trend after the epidemic, about 30% of adolescents failed to fully recover from the series of psychological symptoms induced by pandemic-related stressors and a subset of this population experienced a worsening of their symptoms[64]. At the same time, we found that females had a higher incidence of three suicidal-related behaviors than males, which was consistent with previous studies[65,66]. This gender disparity may be associated with differences in physical and psychological characteristics between males and females, as well as sociocultural factors. Compared to males, females are more likely to exhibiting internalizing symptoms, including depression, anxiety, and withdrawal[67]; at the same time, female adolescents are exposed to a higher number of suicide risk factors[68] including: eating disorders, menstruation with low estrogen (and serotonin) levels, unwanted pregnancy, domestic violence and childhood abuse, etc. In addition, family factors, including relationships with father and mother; relationship between parents and school factors, including relationships with teachers and classmates, and academic stress, also influenced suicide-related behaviors. Zygo[69] and Welty[47] et al. suggested that family and school factors are important influences on the occurrence of suicidal behavior in adolescents and that a disharmonious family atmosphere as well as poor interpersonal relationships at school tend to create extreme, negative personalities in individuals, and when faced with a negative life event, individuals tend to choose extreme methods, such as self-injury and suicide, due to the inability to receive effective social and emotional support[70,71]. Given the sociocultural factors and enrollment pressure in China[72], academic pressures and achievements tend to be related to adolescents' parent–child and peer relationships[73,74] and psycho-emotional states[75], which in turn have the potential to influence the suicide-related behaviors of individuals[76]. However, this study did not find significant differences in the prevalence of suicide-related behaviors between urban and rural areas, which is not quite consistent with previous studies indicating a higher risk of suicidal behaviors among adolescents in rural regions[77,78]. This discrepancy may be attributed to the fact that, on the one hand, based on prior studies, there has been increasing societal attention to the mental and physical health of rural adolescents, and the psychological service infrastructure in rural areas has been progressively improved[79]; on the other hand, it is possible that the differences in environmental factors between urban and rural settings[80,81], such as the lack of greenery, greater socioeconomic disparities, and heavier academic pressures in urban areas, may contribute to more severe psychological crises among urban adolescents, and then reduce the differences in suicide risk between urban and rural adolescents. Notably, we found that suicidal ideation, suicide planning, and suicide attempts were associated with each other, a finding that is not surprising, as studies have suggested that suicide completion tends to go through the three stages of suicidal ideation, planning, and attempting[7], that suicidal ideation appears to be a significant predictor of suicide attempts[82,83], and that individuals with a premeditated plan are more likely to have more severe attempts than those who have no suicide plan[84].

In line with previous findings[85], increased levels of depressive symptoms could increase the risk of suicidal-related behavior. Self-punishment mechanisms[86] pointed out that self-punishment (e.g., self-harm) is triggered by negative emotions (guilt, shame, self-deprecation and disgust) while simultaneously moderating negative emotions. Relevant studies have shown that 90% of people who die by suicide suffer from mental illness at the time of their suicide[87] and that psychiatric experiences could increase the likelihood of recurring suicidal thoughts and lead to a nine-fold increase in the rate of attempted suicides[88]. Suicide is often a form of experiential avoidance[40]. According to the three-step theory of suicide[89], individuals tend to avoid scenarios or stimuli that trigger emotional and/or physical harm, but this often leads to long-term negative effects, such as chronic stress; chronic stress may cause depressive symptoms and negative moods, manifested as pain and hopelessness, and when depressed moods, feelings of hopelessness, and lack of social connection to life are intertwined, suicidal ideation can emerge and intensify, which in turn may develop into suicide attempts. Moreover, the severity of depressive symptoms was also closely related to an individual's deficits in executive functioning[90], which is considered to be the basis of an individual's emotion regulation in the face of stressors[91], whereas adolescents, because of their immature level of cognitive development, may be more susceptible to maladaptive emotion-regulation strategies, such as avoidant types, when depressive symptoms appear; as the symptoms become more severe, adolescents may resort to more extreme forms of avoidance to alleviate their distress, such as suicide[92]. Han et al. found that middle school students with poor cognitive reappraisal tended to exhibit lower psychological resilience and mental health, and were more inclined to adopt negative coping style[93]. A study in adults suggested that better cognitive function was associated with the use of more problem-focused coping strategies, which aim

to take steps to remove the stressor and reduce its impact through seeking information, planning, and conflict resolution; worse cognitive function was linked to more emotion-focused coping strategies, which focused on negative thoughts and escaped the situation by avoidance, denial, and wishful thinking[94].

We also found that health literacy level was significantly associated with depressive symptoms. Previous studies also showed that levels of health literacy were closely associated with psychological disorders such as depression and anxiety[41,95]. Adolescents with low levels of health literacy are limited by their level of knowledge, ability to read and comprehend, and access to relevant knowledge are often unconscious of the depressive mood that has already occurred[96], which, combined with their negative help-seeking attitudes and intentions[97], leads to delays in early guidance and treatment, then resulting in the further development of depressive symptoms. Bozbulut et al. revealed that low health literacy could increase the risk of alexithymia among adolescents[98]. Adolescents with poor interpersonal, expressive, and communication skills are mostly sensitive and introverted, and support they can perceive from friends and family is usually limited[99], causing the accumulation of negative emotions, in turn contributing to psychological symptoms and illnesses[100]. In addition, according to the knowledge, attitude and practices (KAP) model[101] and theory of planned behavior[102], knowledge and attitudes are key factors that guide the establishment and development of individual behaviors. Studies have found that low health literacy is associated with health risk behaviors such as substance abuse[103], Internet addiction[51], which are also risk factors for the development of depression[104]. Therefore, we suggest that improving the health literacy level of adolescents may be an effective way to protect against depression. Relevant health literacy enhancement activities can be carried out based on schools and communities. For example, health education classes can be included in daily school curricula, health education teaching materials and resources suitable for different age groups can be developed; communities can also organize health literacy awareness campaigns, such as role-playing scenarios, debate competitions and lectures to encourage broad participation, in addition to focusing on adolescent group, parents can also be effectively involved to promote health literacy levels. Although adolescence is a stage of high prevalence of mental disorders, it is also considered to be an important stage for improving and upgrading the level of health literacy due to adolescents' strong ability to accept new things and their plasticity[105].

The mediation analysis showed that inadequate health literacy level was a risk factor for the occurrence of suicide-related behaviors, while depression mediated the relationship between health literacy and suicidal ideation, planning, and attempts, which aligns with previous research findings. For example, Yao and colleagues found that depressive symptoms mediated the relationship between mental health literacy and suicidal ideation among college students[106]. Guo's research indicates that health literacy levels predicted depressive symptoms and suicide-related outcomes 12 months later among middle school students[20]. Currently, there is relatively little research on the correlation between general health literacy and suicide-related behaviors, but existing evidence has shown that inadequate mental health literacy is a risk factor for suicide-related behaviors[58]. Individuals with inadequate levels of mental health literacy are prevented from seeking help due to stigma[107] and a lack of awareness of their own psychological and behavioral problems[108]; as negative psychological emotions accumulate without timely relief, individuals often resort to self-injury, suicide, and other extreme means of venting their frustrations[109]. A Chinese psychological autopsy study showed that individuals who died by suicide had a high prevalence of psychological disorders relative to the control group, with depression accounting for 40% of the cases, but only 7% of them had received professional psychological counselling[110]. Therefore, mental health literacy improvement may be an effective approach to the prevention of mental behavioral problems, while general health literacy, which includes the domains of spiritual growth and stress management, is closely related to mental health literacy. Furthermore, together with the results of this study, we suppose that improving general health literacy among adolescents can not only prevent suicide-related behaviors directly but also indirectly by alleviating depressive symptoms. Therefore, this study can also provide insights for policy-making, including but not limited to integrating mental health education into public life and disseminating mental health knowledge through media and social platforms to reduce public misconceptions and stigmatization of mental health issues. At the community level, establishing mental health service centers to provide effective mental health screening and counseling services is recommended. Additionally, targeted health education and intervention programs should be designed for populations with lower health literacy levels.

However, there are several limitations in our study that need to be noted. First, the population in this study was from the same province, so the universality and generalizability of the findings remain to be tested in a more representative sample. Second, due to cultural taboos and stigmatization, the prevalence of suicide-related behaviors may be underestimated, and the study used a self-reported format to assess suicide-related behaviors in the past 12 months, recall bias was unavoidable. Future studies could improve the accuracy of screening for suicide-related behaviors by combining other validated suicide risk screening tools and collecting the frequency of suicide-related behaviors. Furthermore, this study was a cross-sectional research design, and it was unable to elucidate the dynamic characteristics of change and causal relationship between health literacy and suicide-related behaviors. Longitudinal research designs can be used to further reveal the dynamic effects of health literacy on adolescents' suicide-related behaviors in the future.

The present study reported that the 12-month prevalence of suicidal ideation, planning, and attempts among Chinese middle school students was 26.62%, 9.27%, and 4.55%, respectively, and it also explored the mediating role of depressive symptoms on the association between general health literacy and suicide-related behaviors. This study emphasizes the importance of improving health literacy among adolescents to prevent depression and suicide-related behaviors. Integrated school-based and community-based education programs are needed to enhance adolescents' health literacy and mitigate these risks.

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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Author contributions
Ronghuinan Zhang, Aini Liu, and Yu Luo contributed to the study design and data collection. Yu Luo organized the database. Ronghuinan Zhang performed the statistical analysis and wrote the first draft of the manuscript. Aini Liu reviewed and edited the manuscript. All procedural supervision was carried out by Hong Wang and Chang Peng.

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Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate

Ethics approval was granted by the Ethics Committee of Chongqing Medical University (Grant number: 2023028). All procedures were carried out in accordance with relevant guidelines and regulations (Declaration of Helsinki). Informed consent was obtained from all the participants and/or their legal guardians.

Additional information

Correspondence and requests for materials should be addressed to C.P. or H.W.

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