Development and validation of a food and nutrition literacy questionnaire for Chinese school-age children

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Research

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Abstract

Background : This study aimed to develop and validate a Food and Nutrition Literacy Questionnaire for Chinese School-age Children (FNLQ-SC). Methods : A comprehensive literature review and a qualitative study were initially performed to identify food and nutrition literacy dimensions and core components. A cross-sectional survey was conducted in 4359 school-age children, and the junior middle school students were used to analyze the reliability and validity (n=2452). The reliability of the questionnaire was determined by internal consistency. The construct validity was assessed by exploratory factor analysis (EFA), and the content validity was assessed by Pearson correlation coefficient. Results : By literature review and qualitative methods, 19 core components of FNLQ-SC were developed, including five dimensions of food and nutrition knowledge, the ability of access, selection, preparing of food and healthy eating. The overall FNLQ-SC questionnaire had high internal consistency (Cronbach's α = 0.698). The exploratory factor analysis of skill components extracted 5 factors which were included in the conceptual framework, but a little different model, and cumulative contribution of variance accounted to 50.60%. The commonality was more than 0.20 for all components. The Pearson correlation coefficients between dimensions and total questionnaire were from 0.370 to 0.877. For all 4395 students, the average FNLQ-SC score of all participants was 61.91 ± 9.22, the score of knowledge and understanding was higher than that of skill dimensions. Multiple linear regression analysis indicated not only the social demographic characteristics (girls, only child, non-resident in school, urban registered permanent residence, in a more affluent family, and cared by their parents/grandparents with a higher education level), but also the home food environment were the predictors of food and nutrition literacy in school-age children (R^2 =0.226, F =81.401, P <0.05). Conclusion : The developed Food and Nutrition Literacy Questionnaire (FNLQ-SC) had good reliability, and it could potentially be a useful instrument for assessing food and nutrition literacy for Chinese school-age children.

Background

Global Burden of Disease Study 2017 indicated that dietary risks were responsible for 22% of all deaths and 15% of all DALYs among adults globally, even much more in China (being 30.2% and 21.3% respectively) [1]. At the same time, the triple burden of malnutrition (undernutrition, hidden hunger and overweight) threatens the survival, growth and development of children, which is driven by the poor quality of children's diets. Improving dietary habits of children is a societal and multifaceted task, which demands an understanding of the social context, but also food related skills and abilities of individuals. Food and nutrition literacy have become increasingly important concepts in health promotion, which has been defined as the capacity to obtain, process, and understand nutrition information and skills needed to make appropriate nutrition decisions and maintain a healthy diet [2]. Children are during the window period to develop healthy eating behavior, childhood, therefore provides an opportunity that can be utilized by health promoters to establish healthy behaviors that could prevent the development of health problems later in life. Improving children's food and nutrition literacy has been in particular the target of intervention studies and contemporary nutrition policies and actions [3].

In 2008 the national health commission of China officially started the "health literacy promotion action", and China's Health Education Centre established assessment instrument of health literacy, and conducted nationwide surveillance among Chinese residents. In 2018 the percentage of health literate residents increased to 17.06% from 6.48% in 2008. While health literacy assessment instrument can reliably identify individuals

with health literacy skills, it is not specific to nutrition. This distinction is important because literacy is situation-specific, someone's capacity may be perfectly adequate in one setting and marginal or inadequate in another. The health literacy assessment cannot provide information as to the individual's nutrition proficiency.

In other countries there are several instruments to measure food and nutrition literacy, such as the Nutrition Literacy Assessment Instrument (NLAI) [4], the Nutrition Literacy Scale (NLS) [5], the Critical Nutrition Literacy scales (CNL) [6], the Newest Vital Sign (NVS)[7], Food and Nutrition Literacy questionnaire (FNLIT) [8] and so on. Most of them were developed for assessment in adult, except FNLIT, which was for school-age children in Iran. Considering the dietary culture gap among countries and cognition difference between adults and children, the above instruments could not be used in Chinese children.

Overall, the food choices and dietary quality in childhood can affect the lifelong risk of nutrition-related diseases [9]–[10]. According to studies, the adequate nutrition knowledge, optimal dietary behaviors, and the maintenance of a healthy weight are now recognized as key modifiable factors in health promotion and chronic disease prevention [11] –[12]. The food and nutrition literacy level is one way to understand the reasons behind the nutrition-related problems and behaviors among children and adolescents[13]. However, there are no food and nutrition literacy assessment instruments specifically developed and validated for Chinese school-age children. Considering the functional literacy is situation specific and the instruments for measuring Chinese health literacy are likely inadequate to measure food and nutrition literacy. Our study aimed to develop and validate the Food and Nutrition Literacy Questionnaire for Chinese School-age Children (FNLQ-SC), to assess the food and nutrition capacity of children, and provide targets for further nutrition education and intervention.

Methods

Development of Questionnaire

The development of the Food and Nutrition Literacy Questionnaire for Chinese School-age Children (FNLQ-SC) mainly comprised two stages:

Stage 1: the construct of food and nutrition literacy core components for school-age children

Firstly, the conceptual framework and dimensions of food and nutrition literacy in school-age children were preliminarily constructed based on literature review and experts interview, considering the cognitive level and dietary behavior problems of school-age children. In this study food and nutrition literacy is defined as "collection of inter-related knowledge, skills and behaviors required to plan, manage, select, prepare and eat foods to meet needs and determine food intake". According to Nutbeam's hierarchical model, food and nutrition literacy can be classified in three levels as functional, interactive and critical literacy[14]. Functional literacy is the ability to obtain, understand and use information on food and nutrition, including knowledge on various food and nutrition topics, practical skills to gain, select, prepare and eat healthy foods. Interactive literacy is the ability to exchange, share, discuss information on food and nutrition with others and interact with them, participate in shared actions. Critical literacy is the ability to judge food and nutrition information critically, recognize the influence of nutrition and food decisions on the society, understand food as integrative part of a

complex production and distribution process, and recognize the influence of different social conditions on food choice and dietary behavior[8][15]. At the same time, we also refer to the evidence-based Chinese Dietary guideline (2016) as behavior blueprint.

Secondly, qualitative consensus study was conducted to determine the dimension and core components of FNLQ-SC. A two-stage electronically distributed Delphi consultation was held among 15 food and education experts.

Stage 2: questionnaire development

Based on the conceptual framework identified at stage one, a pool of 51 questions was generated to measure core components of food and nutrition literacy, including the Likert-type 5-point questions (I am concerned about food and nutrition information: never, seldom, sometimes, usually, always), choice questions (which of the following snacks is healthier?), and fill-in-the-blank-questions (fill in your height and weight). Because the questionnaire was developed according to the children's real-life situation, sometimes one question assessed more than two components of food and nutrition literacy. So, the reliability and validity were analyzed on the basis of components, not the questions/items.

The professionality of the questionnaire was evaluated by food and nutrition experts in the study steering group, and the readability and difficulty of the questionnaire were evaluated and adjusted by two senior teachers in primary and junior middle schools. After elimination of redundant items, the final questionnaire included 50 questions.

Validation of Questionnaire

Data collection

A cross-sectional survey was conducted in two middle schools and three primary schools in Hebei province of China using convenient sampling method during June 2019. A total of 4359 students from grade 3 to 8 participated in the study.

For all participants, the food and nutrition literacy were assessed using developed FNLQ-SC, social demographic characteristics (age, gender, registered residence, family affluent status, caregiver and their education level), BMI (height, weight), home food environment, and school nutrition education were investigated by self-reported questionnaire. The family affluent status was assessed using adjusted "The Family Affluence Scale (FAS)", which was a six-item scale used in Health Behavior in School-aged Children (HBSC), a WHO collaborative cross-national study[16]. Considering the Chinese family situation, three items were remained, like "Does your family own a car, van or truck?"; "Do you have your own bedroom for yourself?"; "How many times did your family travel for a holiday/vacation last year?". The home food environment comprised family healthy food accessibility, family food rule, family eating behavior, and discussion of nutrition information.

The study protocol was approved by the Peking University Institutional Review Board (Beijing, China) and informed written consent was obtained from children and their guardians.

Reliability tests

Several psychometric properties of the FNLQ-SC were assessed. The samples of junior middle school students were used to analyze the reliability and validity (n = 2452).

The internal consistency reliability was measured by calculating Cronbach's alpha coefficient of total questionnaire, each dimension and each component. For the total questionnaire, alpha coefficient greater than 0.6 indicated acceptable reliability [17]–[18].

The floor or ceiling effects were assessed by the proportion of respondents who received the lowest or the highest score [19].

Validity tests

To assess construct validity of the scale, exploratory factor analysis (EFA) was used to explore whether the statements in the questionnaire reflected the five dimensions of FNLQ-SC. Considering the knowledge and skill dimensions were based on different theoretical framework, so we only analyzed the components of skills dimension by EFA. Kaiser-Meyer-Olkin (KMO) was used to measure sampling adequacy. Bartlett's test of sphericity, and total variance explained were used for the evaluation of factor analysis. An oblique rotation and principal axis factoring (PAF) extraction were used to explore the existing factorial pattern. The number of factors was determined through eigenvalues, percent of explained variance by each factor, scree plot and interpretability criteria.

The content validity was assessed by Pearson correlation coefficient between component, dimension and total questionnaire.

Statistical analysis

Internal consistency, and other parametric tests were computed by using SPSS 25.0. The significance level was set at $P < 0.05$.

The reliability and validity were analyzed on the basis of components, not the questions/items, because some questions assessed more than two components, not only one.

Assessed using FNLQ-SC, the students of grade 7–8 had a full score of 100, while the students of grade 5–6 skipped one question with a full score of 98, and the students of grader 3–4 skipped 4 questions with a full score of 92. The final score was converted in a centesimal measure for comparison.

Results

Core components of food and nutrition literacy of school-age children

A total of 25 core components of food and nutrition literacy in school-age children were proposed preliminarily. A two-round electronically distributed Delphi consultation was conducted. The response rates of both rounds were 100%, and the average authority degree of experts was 0.8767. The mean of total scores (4.47) for all components in the second round was improved compared with that in the first round (4.38), and the total coordination coefficient was 0.224 in the first round and 0.243 in the second round (both $P < 0.001$). Finally, 19

core components of FNLQ-SC were determined, including five dimensions of food and nutrition knowledge, the ability of access, selection, preparing of food and healthy eating, as well as three levels of functional, interactive and critical literacy. As shown in Table 1.

Table 1
The core components of food and nutrition literacy of school-age children

Domain	Dimension	Component
Knowledge and understanding	Knowledge and understanding of food and nutrition	1. Understanding that individual is responsible for his own health and life style. [a] 2. Knowing the resources of food and nutrition information and services. [a] 3. Knowing the food system from production to access to waste. 4. Knowing food groups and their composition. [a] 5. Understanding a variety of food culture. [a]
Skill	Access and planning of food	6. Learning to grow food in the garden, and process home food. [a] 7. Planning quantity of food for less food waste. [a]
	Selecting food	8. Being able to judge the quality of food. [a] 9. Being able to read food labels and nutrition Labeling. [a] 10. Being able to critically judge advertisements, promotions, marketing and everything that's coming your way. [c] 11. Talking to the families and friends about food and nutrition, and say "no" and be able to moderate their intake. [b]
	Preparing food	12. Being familiar with kitchen equipment, and being able to help parents prepare foods and try cooking. [a] 13. Being able to apply basic principles of food safety, like keeping clean hands. [a]
	Eating	14. Being able to estimate food portion size. [a] 15. Eating regularly according to Chinese Dietary Guidelines and Food Guide Pagoda, including plenty of vegetables and fruits, enough dairy and bean products, and less oils, salt and sugars. [a] 16. Being willing to try a variety of foods, without picky eating. [a] 17. Eating healthy snacks. [a] 18. Eating foods which balance physical activity by monitoring weight. [a] 19. Being able to eat in a good table manner, and chewing carefully. [a]

Demographic characteristics of participants

Total of 4359 students of grade 3~8 participated in the study, including 2195 boys (50.36%) and 2105 girls (48.29%). The junior middle school students were used to analyze the reliability and validity (n=2452). The social demographic characteristics of two study samples were shown in Table 2.

Table 2
Demographic characteristics of participants n (%)

Characteristics	Total (N = 4359)	Validity study (N = 2452)
Gender		
Male	2195 (50.36)	1213 (49.47)
Female	2105 (48.29)	1216 (49.59)
Age (years)		
7 ~ 9	237 (5.44)	15 (0.61)
10 ~ 12	1511 (34.66)	70 (2.85)
13 ~ 15	2492 (57.17)	2270 (92.58)
16 ~ 17	61 (1.40)	61 (2.49)
Grade		
3 ~ 4	853 (19.57)	—
5 ~ 6	1054 (24.18)	—
7 ~ 8	2452 (56.25)	2452 (100.00)
Only child		
Yes	1003 (23.01)	520 (21.21)
No	3320 (76.16)	1919 (78.26)
Boarder in school		
Yes	1134 (26.02)	1086 (44.29)
No	3194 (73.27)	1354 (55.22)
Registered residence		
Urban	1643 (37.69)	878 (35.81)
Rural	2616 (60.01)	1520 (61.99)
Family affluent status*		
Poor (≤ 2)	572 (13.12)	334 (13.62)
Medium (3–5)	2183 (50.08)	1306 (53.26)
Affluent (6–7)	1533 (35.17)	788 (32.14)
Caregiver		

Note: The sum of percentages did not add up to 100.00% because of the default value.

* Other caregivers include siblings, baby-sitters and others, except parents and grandparents of children.

Characteristics	Total (N = 4359)	Validity study (N = 2452)
Parents	3430 (78.69)	1948 (79.45)
Grandparents	722 (16.56)	392 (15.99)
Others*	129 (2.96)	65 (2.65)
Caregiver's education level		
Primary school and below	514 (11.79)	220 (8.97)
Junior high school	1733 (39.76)	1203 (49.06)
Senior high school or equivalence	890 (20.42)	451 (18.39)
Junior college	340 (7.80)	137 (5.59)
Bachelor degree or higher	286 (6.56)	126 (5.14)
School nutrition education		
Yes	2534 (58.13)	1296 (52.85)
No	1761 (40.40)	1132 (46.17)
Note: The sum of percentages did not add up to 100.00% because of the default value.		
* Other caregivers include siblings, baby-sitters and others, except parents and grandparents of children.		

Reliability

The overall FNLQ-SC questionnaire had high internal consistency (Cronbach's α = 0.698). Regarding the five dimensions (knowledge and understanding, access and planning of food, selecting food, preparing food, eating), Cronbach's α coefficient was 0.452, 0.300, 0.244, 0.148, 0.436, respectively.

Additional Alpha test be deleting components one at a time showed that removing any components did not result in an increase in Cronbach's alpha. That showed each component had high internal consistency with total questionnaire, as shown in Table 3.

Construct validity

Only components of skill dimension was analyzed by EFA. The Kaiser–Meyer–Olkin (KMO) test showed sampling adequacy (KMO = 0.738), and Bartlett's test confirmed factor analysis was appropriate ($P < 0.001$). Finally exploratory factor analysis (EFA) extracted 5 factors (14 components) with eigenvalue more than 1, and cumulative contribution of variance accounted to 50.60%. The model identified five dimensions as "factor1, selecting and eating", "factor2, access and preparation", "factor3, food label and measurement", "factor 4, picky eating", "factor 5, eating snacks". The commonality was more than 0.20 for all components, as shown in Table 3.

Table 3
Factor analysis results and component analysis of FNLQ-SC

Component	EFA factor loading					Commonality	α if component deleted	Pearson correlation coefficient
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5			
1						0.450	0.631	0.418
2						0.469	0.632	0.372
3						0.337	0.635	0.283
4						0.382	0.626	0.453
5						0.349	0.631	0.376
6	-0.037	0.709*	0.111	0.253	-0.014	0.503	0.633	0.320
7	0.450	0.461	0.092	-0.159	-0.137	0.427	0.633	0.371
8	0.629*	-0.141	0.016	-0.030	0.041	0.392	0.636	0.289
9	0.109	0.036	0.690*	-0.043	0.113	0.437	0.616	0.504
10	0.278	-0.260	0.032	0.434	-0.304	0.491	0.645	0.114
11	0.144	0.311	0.420	-0.140	0.285	0.335	0.620	0.456
12	0.113	0.752*	-0.019	-0.089	0.000	0.374	0.637	0.266
13	0.395	0.045	0.202	-0.375	-0.417	0.416	0.637	0.299
14	-0.060	-0.048	0.665*	0.024	-0.124	0.416	0.636	0.294
15	0.634*	0.176	0.180	0.291	0.142	0.574	0.607	0.720
16	0.085	0.101	0.089	0.743*	-0.006	0.586	0.636	0.292
17	0.168	-0.069	0.076	-0.064	0.799*	0.474	0.641	0.239
18	0.114	0.076	0.539*	0.165	0.003	0.303	0.624	0.496
19	0.678*	0.270	0.052	0.153	0.062	0.545	0.610	0.535

Note: Only skill components were analyzed by EFA. * Factor loading > 0.5

Content validity

The Pearson correlation coefficients among different dimensions were ranged 0.152 ~ 0.400, and correlation coefficients between dimensions and total questionnaire were from 0.370 to 0.877, especially the dimension of knowledge and understanding, selecting food, and eating, whose coefficients were more than 0.6, that showed strong correlation with total questionnaire (Table 4).

The Pearson correlation coefficients between each component and total questionnaire were from 0.114 to 0.504, and coefficients of eight components were less than 0.3.

Table 4

Pearson correlation coefficient among dimensions of FNLQ-SC

Dimension	Knowledge and Understanding	Access and planning of food	Selecting food	Preparing food	Eating	Total
Knowledge and Understanding	—	0.241	0.326	0.167	0.400	0.658
Access and planning of food	0.241	—	0.214	0.257	0.303	0.441
Selecting food	0.326	0.214	—	0.152	0.369	0.657
Preparing food	0.167	0.257	0.152	—	0.188	0.370
Eating	0.400	0.303	0.369	0.188	—	0.877

Assessing food and nutrition literacy and its related factors in school-age children

According to centesimal score, the average FNLQ-SC score of all participants was 61.91 ± 9.22, ranged from 22.83 to 92.86. None of the respondents scored the maximum of 100 or the minimum of 0; therefore, floor or ceiling effects likely did not occur. Among the dimensions, the score of knowledge and understanding (64.78 ± 15.15) was higher than score of skill, and the score of eating skill was the lowest (60.45 ± 11.00).

As shown in Table 5, the children, who was female, only child, non-resident in school, urban registered permanent residence, in a more affluent family, cared by their parents/grandparents with a higher education level, and had nutrition education experience in school, had significantly higher food and nutrition literacy ($P < 0.05$).

Multiple linear regression analysis indicated not only the individual and family's demographic characteristics, but also the home food environment were the predictors of food and nutrition literacy in school-age children ($R^2 = 0.226$, $F = 81.401$, $P < 0.05$), as shown in Table 6.

Table 5

Distribution of food and nutrition literacy in school-age children(n = 4359, mean ± SD)

Variables	Total	Knowledge and Understanding	Access and planning of food	Selecting food	Preparing food	Eating
Total	61.91 ± 9.22	64.78 ± 15.15	61.42 ± 21.28	63.43 ± 14.22	62.03 ± 13.05	60.45 ± 11.00
Gender						
Male	61.28 ± 9.48[a]	64.81 ± 15.37	59.72 ± 21.65[a]	62.40 ± 14.60[a]	61.51 ± 13.55[a]	59.84 ± 11.35[a]
Female	62.72 ± 8.80[b]	64.99 ± 14.74	63.20 ± 20.74[b]	64.66 ± 13.65[b]	62.56 ± 12.41[b]	61.25 ± 10.50[b]
Age (years)						
7 ~ 9	61.55 ± 9.65[a]	62.28 ± 16.59[a]	61.13 ± 20.54[ab]	62.03 ± 15.93[a]	60.38 ± 14.48[a]	61.44 ± 11.13[a]
10 ~ 12	63.39 ± 9.63[b]	65.65 ± 14.94[b]	63.79 ± 22.54[a]	64.25 ± 14.87[b]	61.70 ± 13.71[ab]	62.71 ± 11.28[a]
13 ~ 15	61.30 ± 8.77[ac]	64.86 ± 14.89[b]	60.14 ± 20.45[b]	63.27 ± 13.59[ac]	62.45 ± 12.40[b]	59.25 ± 10.55[b]
16 ~ 17	56.58 ± 7.29[d]	58.71 ± 16.77[a]	60.25 ± 21.95[ab]	58.24 ± 11.89[ad]	60.82 ± 13.91[ab]	54.10 ± 8.86[c]
Grade						
3 ~ 4	61.67 ± 9.22[a]	62.06 ± 15.61[a]	60.76 ± 21.65[a]	63.13 ± 16.57	60.84 ± 14.56[a]	61.24 ± 10.39[a]
5 ~ 6	63.94 ± 9.80[b]	67.20 ± 14.61[b]	66.02 ± 22.53[b]	64.07 ± 13.76	62.05 ± 13.07[b]	63.19 ± 11.77[b]
7 ~ 8	61.13 ± 8.83[a]	64.69 ± 15.06[c]	59.67 ± 20.29[a]	63.25 ± 13.50	62.43 ± 12.45[b]	58.99 ± 10.61[c]
Only child						
Yes	63.66 ± 9.85[a]	66.58 ± 15.44[a]	62.31 ± 21.39	63.95 ± 14.66	61.66 ± 13.59	63.17 ± 11.71[a]
No	61.46 ± 8.91[b]	64.37 ± 14.93[b]	61.17 ± 21.23	63.35 ± 14.03	62.16 ± 12.82	59.70 ± 10.62[b]
Boarder in school						

Note: Different superscript characters (a, b, c, d, e) mean statistical difference among groups (P 0.05). * Other caregivers include siblings, baby-sitters and others, except parents and grandparents of children.

Variables	Total	Knowledge and Understanding	Access and planning of food	Selecting food	Preparing food	Eating
Yes	60.08 ± 8.11[a]	63.66 ± 14.83[a]	58.74 ± 20.01[a]	64.35 ± 13.13[a]	61.81 ± 11.77	56.99 ± 9.45[a]
No	62.62 ± 9.47[b]	65.27 ± 15.16[b]	62.36 ± 21.66[b]	63.15 ± 14.55[b]	62.09 ± 13.45	61.73 ± 11.22[b]
Registered residence						
Urban	64.15 ± 9.48[a]	66.88 ± 15.40[a]	63.51 ± 21.72[a]	63.74 ± 14.67	62.71 ± 13.65[a]	63.82 ± 11.15[a]
Rural	60.64 ± 8.74[b]	63.70 ± 14.69[b]	60.09 ± 20.88[b]	63.36 ± 13.86	61.62 ± 12.62[b]	58.47 ± 10.35[b]
Family affluent status						
Poor (≤ 2)	59.19 ± 8.67[a]	61.16 ± 14.99[a]	55.73 ± 21.52[a]	62.70 ± 14.26[a]	60.54 ± 13.34[a]	57.19 ± 9.96[a]
Medium (3–5)	61.41 ± 8.81[b]	64.79 ± 14.81[b]	60.71 ± 20.93[b]	63.16 ± 14.14[a]	61.62 ± 12.77[a]	59.68 ± 10.60[a]
Affluent (6–7)	63.78 ± 9.57[c]	66.37 ± 15.25[c]	64.47 ± 21.24[c]	64.30 ± 14.20[b]	63.17 ± 13.20[b]	62.87 ± 11.39[b]
Caregiver						
Parents	62.14 ± 9.11[a]	64.98 ± 15.00[a]	61.65 ± 21.01[a]	63.50 ± 14.13[a]	62.30 ± 12.85[a]	60.74 ± 10.92[a]
Grandparents	61.77 ± 9.14[a]	65.22 ± 14.71[a]	60.79 ± 21.75[a]	64.08 ± 14.16[a]	61.10 ± 13.16[b]	60.02 ± 10.91[a]
Others*	57.68 ± 10.66[b]	59.00 ± 18.09[b]	57.07 ± 25.62[b]	59.43 ± 15.27[b]	59.92 ± 16.04[c]	56.17 ± 12.06[c]
Caregiver's education level						
≤Primary school	59.60 ± 9.84[a]	62.79 ± 15.16[a]	60.00 ± 22.57[a]	61.05 ± 15.61[a]	61.59 ± 13.74[ab]	57.59 ± 11.50[a]
Junior high school	61.13 ± 8.40[b]	64.10 ± 14.62[a]	60.04 ± 20.00[a]	63.41 ± 13.45[b]	61.40 ± 12.60[a]	59.33 ± 10.03[b]
Senior high school	63.80 ± 9.11[c]	67.20 ± 14.86[b]	62.87 ± 22.81[b]	64.96 ± 14.11[c]	61.71 ± 13.43[ab]	62.80 ± 10.82[c]

Note: Different superscript characters (a, b, c, d, e) mean statistical difference among groups (P 0.05). * Other caregivers include siblings, baby-sitters and others, except parents and grandparents of children.

Variables	Total	Knowledge and Understanding	Access and planning of food	Selecting food	Preparing food	Eating
Junior college	64.85 ± 9.75[c]	66.84 ± 16.13[b]	64.67 ± 20.80[b]	64.81 ± 14.26[bc]	63.34 ± 13.58[bc]	64.60 ± 11.68[d]
≥Bachelor	66.93 ± 9.51[d]	69.25 ± 15.07[c]	65.12 ± 21.48[b]	67.58 ± 14.58[d]	64.76 ± 12.17[c]	66.55 ± 11.24[e]
School nutrition education						
Yes	63.54 ± 8.85[a]	66.82 ± 14.58[a]	63.78 ± 20.85[a]	65.04 ± 13.72[a]	62.63 ± 12.93[a]	62.12 ± 10.74[a]
No	59.71 ± 9.16[b]	62.06 ± 15.32[b]	58.14 ± 21.47[b]	61.32 ± 14.48[b]	61.21 ± 13.03[b]	58.15 ± 10.87[b]

Note: Different superscript characters (a, b, c, d, e) mean statistical difference among groups (P 0.05). * Other caregivers include siblings, baby-sitters and others, except parents and grandparents of children.

Table 6

Multiple linear regression analysis of food and nutrition literacy related factors in school-age children

Variables*	β	SE	B	T	P
Constant	38.304	1.494	—	25.632	< 0.001
Gender	-1.215	0.275	-0.066	-4.415	< 0.001
Age	-0.207	0.079	-0.040	-2.616	0.009
Only child	1.177	0.348	0.054	3.380	0.001
Registered residence	0.991	0.326	0.053	3.039	0.002
Family affluent status	0.357	0.086	0.067	4.174	< 0.001
Caregiver					
Parents	—				
Grandparents	-0.254	0.370	-0.010	-0.687	0.492
Others	-3.020	0.825	-0.054	-3.659	< 0.001
Caregiver's education level	0.961	0.147	0.113	6.525	< 0.001
Fruit accessibility at home	2.229	0.193	0.181	11.575	< 0.001
Video-watching when eating at home	1.239	0.144	0.129	8.634	< 0.001
Discussion nutrition information with families	1.509	0.144	0.159	10.493	< 0.001
Family eating out	1.829	0.181	0.154	10.132	< 0.001
School nutrition education	2.432	0.285	0.130	8.536	< 0.001

Variable values: Gender (Male = 1, Female = 0); Only child (Yes = 1, No = 0); Registered residence (Urban = 1, Rural = 0); Caregiver's education level (Primary school and below = 1, Junior high school = 2, Senior high school or equivalence = 3, Junior college = 4, Bachelor degree or higher = 5); Home food environment variables like "fruit accessibility at home" "Video-watching when eating at home" "Discussion nutrition information with families" "Family eating out" were valued with same options (Rarely = 1, Sometimes = 2, Often = 3, Always = 4); School nutrition education (Yes = 1, No / forgotten = 0).

Discussion

Our study developed a questionnaire to assess the food and nutrition literacy in Chinese school-age children, including five knowledge and skill dimensions, and 19 core components. The total questionnaire had high internal consistency (Cronbach's α = 0.698). Exploratory factor analysis of skill components extracted 5 factors which were included in the conceptual framework, but a little different model. The commonality was more than 0.20 for all components. The Pearson correlation coefficients between dimensions (knowledge and understanding, selecting food, eating) and total questionnaire were more than 0.6, that indicated strong correlation. Using the questionnaire to assess the food and nutrition literacy and its related factors in school-age children, the results showed the literacy was low; not only social demographic characteristics, but also the home food environment were the predictors of food and nutrition literacy in school-age children.

Improving dietary habits demands food related skills and abilities of individuals, and an understanding of the social context. In this regard, nutritional science and education researchers are currently discussing the concepts of nutrition literacy and food literacy. A systematic review (2018) on definitions of nutrition literacy and food literacy[15] revealed that that nutrition literacy and food literacy are seen as specific forms of health literacy, and represent distinct but complementary concepts. Definitions of nutrition literacy mainly described the abilities necessary to obtain and understand nutrition information, and food literacy incorporated a broader spectrum of theoretical and practical knowledge and skills to apply information on food choices and critically reflect on the effect of food choice on personal health and society. Since food literacy is based on a more comprehensive understanding of health behaviors, it is the more viable term to use in health promotion interventions. In this study, the term “food and nutrition literacy” was used, and defined as “collection of inter-related knowledge, skills and behaviors required to plan, manage, select, prepare and eat foods to meet needs and determine food intake”. We focused not only the ability of access and understand nutrition information, but also the ability to judge and apply nutrition information and the ability to communicate and act upon this information in the broader social environment, to address nutritional barriers in personal, social, and global perspectives[6]. Based on the conceptual framework we developed the Food and Nutrition Literacy Questionnaire for Chinese School-age Children (FNLQ-SC) by literature review, experts interview and qualitative consensus study, which included five dimensions of food and nutrition knowledge, the ability of access, selection, preparing of food and healthy eating, as well as three levels of functional, interactive and critical literacy. Literatures showed all definitions of food and nutrition literacy contained elements of functional literacy, but only a few definition described skills that could be assigned to interactive and critical literacy since this definition was based on Nutbeam’s model of health literacy [6][15]. And core elements of all conceptual frameworks included practical knowledge and skills to regulate food intake, including skills for planning meals, selecting, and preparing food. The Nutrition Literacy Assessment Instrument (NLAI) for American adults included the following domains: appreciation of relationships between nutrition and health, knowledge of macronutrients, food measurement skill, numeracy and label reading, and skill in grouping like foods [4][20]. Australian experts identified eleven components of food literacy, which were grouped into four domains: planning and management; selection; preparation; and eating[21]. The Food and Nutrition Literacy (FNLIT) [8] for elementary school children in Iran measured two domains with 6 subscales, including: 1) cognitive domain: understanding and knowledge; 2) skill domain: functional, food choice, interactive, and critical skills. Overall, despite the domain, dimension and components are different according to different food and nutrition definitions, the conceptual framework is similar, and future research should focus on multi-dimensional tool including interactive and critical literacy, and access, selection and preparation of food besides healthy eating.

We used Cronbach’s α coefficient to analyze the internal consistency. The total Cronbach’s α was 0.698, that indicated the total questionnaire had high internal consistency. But the Cronbach’s α coefficient of various dimensions was low, ranged from 0.148 to 0.452. A possible explanation for the low internal consistency values of dimensions is that internal consistency reliabilities values depend on the number of items in the scale [8]. Since the “planning” “selection” “preparation of food” dimensions consisted of two, four and two components respectively, this could have resulted in lower internal consistency values. Additionally, There are many other possible reasons for a low alpha value, such as poor inter-relation between components and heterogeneous constructs[22], the sample size, or content cross in different dimensions. But the lower reliability estimates will not necessarily negate the value of the dimensions, since expert panel rated the components as relevant.

Without evidence of acceptable internal consistency, we recommend that the total score be used instead of the subscale (dimension) scores.

Considering the knowledge and skill dimensions was based on different theoretical framework, so some studies independently analyzed the variables of cognitive and skills domains by exploratory factor analysis (EFA)[8]. In the study only skill components were analyzed and extracted 5 factors with eigenvalue more than 1. The EFA model was a little different with the conceptual framework of the study, which identified five skill dimensions as “selecting and eating”, “access and preparation”, “food label and measurement”, “picky eating”, “eating snacks”. Preliminarily the “picky eating” and “eating snacks” were not developed as separate dimension in the conceptual framework, both of which were included in “eating” dimension, despite they are important eating behavior for children. Considering the conceptual framework was developed logically through literature review, expert interview and consistency study, which shouldn’t be modified easily, especially in an unlogical model. Later we will modify or remove the questions to adjust the framework. Components analysis showed the factor loading of some components was lower than 0.40, but the commonality was more than 0.20 for all components. And removing any components did not result in an increase in Cronbach’s alpha coefficient, which indicated each component had high internal consistency with total questionnaire.

Using above developed questionnaire, we assess the food and nutrition literacy level in 4359 school-age children of grade 3 ~ 8. The results were similar to other studies. The FNLIT assessment of 803 students aged 10–12 years from elementary schools in Tehran city of Iran showed that more than half of the children (69%) had high levels of FNLIT in the cognitive domain, but in the skills domain, very few (3%) scored highly[23]. Our study also showed the score of knowledge was more than that of skill dimensions in school-age children. The FNLIT study identified some associations between the total FNLIT and its subscales and sociodemographic variables including gender, parent’s education and age, birth order. Their results indicated that girls feel more able to exert choice and control over food and nutrition decisions than boys, but may be less able to do so in practice. Our results also showed the total literacy of girls were higher than boys, but the critical literacy was lower than boys ($P > 0.05$). Additionally, our results showed the home food environment was significantly correlated with children's food and nutrition literacy. The total score of food nutrition literacy was higher for the children who often had fruits at home, rarely ate out, eating without screen, and communicated food and nutrition information with families frequently ($P < 0.05$). Overall, these results are a general reminder to schools of the different learning needs of children from different family backgrounds, children in rural areas and younger age, with a large number of family children and poor family economic status and food environment, should be the main target population of nutrition education and nutrition improvement. The study highlights the need for continuous improvement in the nutrition education curriculum of schools in China, particularly highlighting the importance of giving greater attention to the development of practical food and nutrition skills alongside more traditional food and nutrition knowledge. Additional studies are needed to more fully assess and understand the predictors of FNLQ-SC.

Conclusion

Overall, the FNLQ-SC has good reliability, and it could potentially be a useful instrument for assessing food and nutrition literacy for Chinese school-age children, despite the convenience sampling and self-reported bias. The development and validation of an appropriate instrument is an essential step for food and nutrition literacy

research of children. To our knowledge, this is the first reported food and nutrition literacy questionnaire for school-age children in China. The questionnaire could potentially be used in other Chinese population. Furthermore, the FNLQ-SC can help to identify the target population of children's nutrition education. Therefore, it will be useful for developing targeted interventions to improve the food and nutrition literacy of school-age children and improve their dietary behavior, thus further improve their health.

Declarations

Ethical Approval and Consent to participate The study protocol was approved by the Peking University Institutional Review Board (Beijing, China).

Consent for publication Informed written consent was obtained from children and their guardians.

Availability of supporting data The datasets analysed during the current study available from the corresponding author on reasonable request.

Competing interests The authors declare that they have no competing interests or financial disclosures.

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Authors' contributions TL assisted in designing the questionnaire, organized the investigation and was a major contributor in writing the manuscript. XS assisted in designing the questionnaire, and analysis of the construct validity. NL and JS assisted in the investigation and edited the manuscript. GM guided questionnaire designing and data analysis. WZ assisted in designing the questionnaire, guided analysis and edited the manuscript. All authors read and approved the final manuscript.

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