

# Development and Validation of Nutrition Literacy Scale for Middle School Students in Chongqing, China: A Cross-Sectional Study

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## Research

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# Abstract

## Background:

Nutrition literacy has a positive effect on health and its measurement has no consensus. This study was performed to develop the Chongqing Middle school student Nutrition Literacy Scale (CM-NLS) and measure its reliability and validity.

## Methods:

Three experiments were conducted. Firstly, a theoretical framework and an initial item pool of CM-NLS were established based on the literature review. Secondly, the two-round Delphi method was used to explore the suitable acceptance indicators and items. Thirdly, item evaluation and reduction were performed using the classical test theory. In addition, the items in the final CM-NLS were tested for their validity and reliability amongst 462 middle school students. The construct validity was assessed using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The internal consistency reliability and split-half reliability were evaluated using Cronbach's alpha coefficients.

## Results:

The finalised CM-NLS consisting of 52 items that were based on three primary indicators (functional, interactive and critical) and six sub-indicators (obtain, understand, apply, interact, medial literacy and critical skill) was developed and validated. EFA suggested six factors explaining 69.44% of the total variance (Kaiser–Meyer–Olkin test = 0.916, Bartlett's test  $\chi^2 = 5854.037$ ,  $P < 0.001$ ). CFA showed that the model fit the data adequately, with  $\chi^2/df = 1.911$ , root mean square error of approximation = 0.063, goodness-of-fit index (GFI) = 0.822 and adjusted goodness of fit index (AGFI) = 0.790. The total CM-NLS Cronbach's alpha values of internal consistency and split-half reliability were 0.849 and 0.521, respectively, with reasonable reliability.

## Conclusions:

CM-NLS is a valid and reliable instrument to measure nutrition literacy amongst middle school students. It provides the scientific basis for the evaluation of the nutrition literacy level of middle school students in Chongqing and the implementation of nutrition education strategies.

## Introduction

The prevalence of childhood obesity has been on the rise in recent years<sup>1</sup>. The Global Burden of Disease data showed that approximately 107.7 million children worldwide were obese in 2015<sup>1</sup> and nearly 124 million children are expected to be obese by 2025 in the world<sup>2</sup>, 49.48 million by 2030 in China<sup>3</sup>. According to studies, childhood obesity is closely associated with chronic non-communicable diseases, such as hypertension, diabetes and cardiovascular disease<sup>4–6</sup>. The important factors affecting childhood obesity, such as children's dietary patterns (number, regularity and duration of meals), fast-food consumption habits and food choices, are strongly related to nutrition literacy<sup>7–9</sup>.

Nutrition literacy is an emerging term defined as 'the degree to which people have the capacity to obtain, process and understand basic nutrition information'<sup>10</sup>. Children with high levels of nutrition literacy could develop healthy dietary habits and food purchasing behaviour<sup>11</sup>, whereas low nutrition literacy has been shown to be associated with unhealthy diets<sup>8, 12, 13</sup>.

Although nutrition literacy has emerged as an area of increasing research focus in many countries, only a limited number of tools for assessing children and adolescents are available. In 2017, Asakura et al. developed the Nutrition Knowledge Questionnaire for primary school children consisting of a four-part test based on the understanding of terms, awareness of dietary recommendations, using the information to make dietary choices, awareness of diet-disease associations<sup>14</sup>. However, interactive nutrition literacy (INL) and critical nutrition literacy (CNL) assessment was lacking. The Adolescent Nutrition Literacy Scale developed by Bari contains 29 attitude statements under three sub-dimensions<sup>15</sup>. Food and Nutrition Literacy evaluated the cognitive and skill domain, which was used to measure the validity and reliability of food and nutritional literacy amongst Iranian children<sup>16</sup>. Nutrition literacy is influenced by culture and society. The tools used to measure nutrition literacy should be culture-specific but the two existing evaluation instruments are not suitable for Chongqing<sup>17, 18</sup>. Different regions in China have different dietary cultures, thus, the national questionnaire could not be fully applied for regional survey<sup>19</sup>. In China, no consensus tools are available to measure nutrition literacy amongst school children.

This study aimed to develop and validate a scale to assess the nutrition literacy of middle school students in China and provide a scientific basis for the assessment of the nutrition literacy level of these students.

## Methods

### Study Design and Participants

The study consisted of three consecutive phases. In the first phase, the Chongqing Middle school student Nutrition Literacy Scale (CM-NLS) test pool items were developed. In the second phase, 18 experts working in child nutrition were invited for a two-round e-Delphi to complete the construction of the framework and initial items. In the third phase, 462 participants were tested, the items were revised and the reliability and validity of CM-NLS were tested. Figure 1 shows the whole process of questionnaire design modification.

# Phase 1: Literature review and design of initial items

## Literature review

A comprehensive electronic database search was conducted in PubMed, Web of Science and China National Knowledge Infrastructure from inception to January 2020 to retrieve relevant articles published in English and Chinese. 'Nutrition literacy' and 'Nutritional literacy' were used as search keywords to collect the relevant literature on nutrition literacy. All studies retrieved were read in full, focusing on the definition, field and dimension of nutrition literacy. In summary, this step was used to guide the conceptual framework construction and initial item generation.

## Theoretical Framework

This step aimed to determine a suitable conceptual framework based on the theoretical framework of health literacy<sup>20</sup>, with a comprehensive review of existing nutrient literacy questionnaires and other assessment tools<sup>16, 21–27</sup>.

# Phase 2: Assessment of content validity by two rounds of expert consultation

The purpose of this step was to identify if the questionnaire items generated in the previous step were sufficiently acceptable, comprehensive, and relevant to nutrition literacy from the perspective of professionals. A total of 18 experts (mean age = 41.67 years, mean age of nutrition work = 12.28 years) in the field of children's nutrition education were invited to evaluate the concepts of nutrition literacy by E-mail, all levels of indicators and the items used in the tool. They were asked to comment on the importance, feasibility of each indicator using a 5-Likert scale, comment on the importance and sensitivity of each item using a 10-Likert scale, respectively. We kept the indicator which mean of importance and feasibility was 3.50 and above; the coefficient of variation was 0.30 and below. We kept the items which mean of importance and feasibility was 7.00 and above; the coefficient of variation was 0.30 and below<sup>28, 29</sup>. They were also can put forward some suggestions on the deletion and adjustment of items on the open question, which mainly to learn more about the experts' thoughts on the questionnaire.

# Phase 3: Pilot Study And Confirmation Of Validation

## *Item Generation*

After the two-round Delphi method was conducted, the CM-NLS, which included 21 single-choice questions, three multiple-choice questions, one order question and 34 Likert-type questions, was used in 462 middle school students to confirm the validity of the scale.

## *Pilot study*

### Sample

The convenience sampling method was used to recruit students from a middle school in Chongqing from June 2020 to July 2020. The research design of this study utilized a uniform resource locator (URL) invitation, with a QR (Quick Response) code embedded, providing access to the questionnaire to participate. The students who were asked to fill out the questionnaire, anonymous, without mentioning compensation. Based on the exclusion criteria, we excluded those who were unwilling to participate and did not fill in the questionnaires completely. Most participants completed this scale for approximately 15 minutes.

### Classical Test Theory (CTT)

The techniques of CTT were applied to measure some observable information (scale scores) to obtain insights into variables (nutrition literacy level of middle school students) that could not be directly observed<sup>30</sup>. The following eight criteria were used to determine the questions included in the tool<sup>31</sup>:

- 1) Frequency analysis: the item response rates ranged from 98.60% to 100%, with no response rate exceeding 80% on either option.
- 2) Coefficient of variation (CV): the deleted CV of items  $\geq 0.25$  or/and standard deviation (SD)  $< 0.9$ .
- 3) Discriminant validity: according to the scores of 27% percentile before and after the total score of the scale<sup>32, 33</sup>, the high and low groups were divided and the items with no difference in scores between the two groups were deleted ( $P > 0.05$ ).
- 4) Intra-class correlation coefficient (R): the R between all items under the same sub-indicator and the items with r value low than 0.2 or greater than 0.9 were deleted.
- 5) Entry–dimension consistency: the R between all items under the same sub-indicator and the items with r value low than 0.2 or greater than 0.9 were deleted.
- 6) Item-dimension R: the R between one item and one dimension should be greater than the R between the item and other dimensions.
- 7) Factor analysis: excluding the maximum factor load  $< 0.4$  or each common factor item containing  $< 3$  items.
- 8) Cronbach's alpha coefficient: if an item was deleted and a significant increase was present in the alpha coefficient, then deletion was considered.

Items with three or more of the above criteria for deletion should be deleted.

#### Face Validity

The face validity of the questionnaire was verified in accordance with the evaluation of middle students and experts. At the end of the questionnaire, an open question was set, mainly by asking the respondents about the questions they encountered when filling out the questionnaire (e.g. is there any difficult or ambiguous question in the questionnaire?) to verify the face validity.

#### Content Validity

In this study, content validity index (CVI) was used to evaluate the content validity. Eighteen experts were asked to measure the correlation between each item of the scale and the index content of the scale and were required to use 0 (no) and 1 (yes) to evaluate whether the items could properly reflect the nutrition literacy of students. The items with the CVI value of 0.7 or above were kept<sup>34</sup> (**Additional file 1: Supplementary Material S1**).

#### Construct Validity

Exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used to evaluate the structural validity only on Likert-type items. The sample was randomly divided into two: one for EFA and the other for CFA. Principal component analysis was firstly performed unrotated by using maximum likelihood extraction and (determining the number of factors to retain) the number of factors was determined using the following criteria: the eigenvalue-greater-than-one rule (K1), the percentage explained by each factor, scree plot, Kaiser–Meyer–Olkin (KMO) and Bartlett's test<sup>35</sup>. Then, CFA was used to validate the content and characteristics of the basic constructs, whilst the choice of items was validated using EFA. Evidence of model fit was evaluated using indices of absolute fit and GFIs. The reasonable threshold levels of these indices for CFA were considered as  $\chi^2$  test results  $P > 0.05$ ,  $\chi^2/df < 3$ , root mean square error of approximation  $< 0.08$ , GFI  $> 0.9$  and AGFI  $> 0.9$ <sup>36</sup>.

#### Reliability

The reliability of the scale was evaluated by internal consistency (Cronbach's alpha) and split-half reliability was used to represent the reliability of the total scale and each dimension.

#### Statistical analysis

SPSS 22.0 and STATA 16.0 were used for data analysis and AMOS 23.0 was used to conduct the confirmatory factor analysis, which was only used on Likert-type items, whilst STATA's tetrachoric correlation was used for binary items (10 true/false items).

Table 1  
Basic demographic characteristics

variables		N	%
Age (mean, SD)		13.38	1.05
Gender	Boy	218	47.2
	Girl	244	52.8
Ethnic	Han	454	98.3
	Minorities	8	1.7
grade	7	192	41.6
	8	270	58.4
Whether a boarding	Yes	197	42.6
	No	265	57.4
Whether an only child	Yes	94	20.3
	No	368	79.7
Number of children in the family*	2	223	61.0
	≥ 3	145	39.0
Primary caregiver	Father	290	62.8
	Mother	397	85.9
	Grandparents	65	14.1
	Relatives	25	5.4
	Others	13	2.8
Father's education level	Primary schools and below	55	11.9
	Junior high school	238	51.5
	Senior high school/technical secondary school/vocational high school	94	20.3
	College/bachelor degree or above	51	11.0
	Don't know	24	5.2
Mother's education level	Primary schools and below	91	19.7
	Junior high school	222	48.1
	Senior high school/technical secondary school/vocational high school	77	16.7
	College/bachelor degree or above	47	10.2
	Don't know	25	5.4
Father's career	Party and government officials	19	4.1
	Enterprise personnel	85	18.4
	Professional and technical personnel	181	39.2
	Agricultural laborer	32	6.9
	No employment or layoff	46	10.0
	Don't know	99	21.4
Mother career	Party and government officials	7	1.5
	Enterprise personnel	63	13.6
	Professional and technical personnel	176	38.1
	Agricultural laborer	70	15.2
	No employment or layoff	42	9.1
	Don't know	104	22.5

\*Refers to a student who is not an only child in the house

## Results

### Phase 1: Literature Review And Design Of Initial Items

#### Literature review

We consulted the studies on the development of nutrition literacy assessment tools in different regions. At present, the existing nutrition literacy assessment tools mainly focus on the evaluation of clinical patients, and some of them are used for children's parents and adults<sup>16, 37–39</sup>. Liao, L et al. compiled an evaluation tool suitable for college students according to Dietary Guidelines in Taiwan<sup>40</sup>. The Peking University team has established nutrition literacy core items for the Chinese people, old people, preschool children, and pregnant women<sup>18, 41 42, 43</sup>. However, none of these instruments is suitable for evaluating the nutrition literacy of middle school students in Chongqing with the deference of region and culture.

#### Conceptual framework development and initial questionnaire item generation

The framework was designed based on Nutbeam's hierarchical model of health literacy, with classical functional, interactive and critical levels<sup>20</sup>. Functional nutrition literacy (FNL), as the lowest level, was defined as the ability to access, understand and use nutritional information. At the middle level, INL was defined as the capacity to obtain and exchange nutrition information that improves health through interaction and engagement in various forms of nutrition communication. At the highest level, CNL was defined as the ability to critically evaluate and appraise nutritional information, advice and recommendations from various sources with the right perspective (**Additional file 1: Supplementary Material S1**). The content was designed based on the definition of nutrition literacy (the ability of individuals to acquire, understand and process/use basic nutrition information)<sup>25–27</sup> and other dimensions of existing nutrition literacy assessment instruments<sup>21–23, 40, 44, 45</sup>. A nutrition literacy scale framework structure and item pool containing three primary indicators, nine secondary indicators and 61 items were constructed based on Yuen et al.'s study and other literature contents<sup>16, 24, 25, 29, 30</sup>. Functional nutrition literacy includes two acquisition skills, 18 understanding skills and 24 application skills. Interactive nutrition literacy includes one interactive skill, two emotional skills and four discussion skills. Critical nutrition literacy includes four items of media literacy, three items of analytical skills and three items of evaluation skills.

### Phase 2: Assessment Of Expert Consultation

After two rounds of expert consultation, we deleted, added and modified the items according to the experts' opinions, a pool of 59 items was formed to measure three domains (functional, interactive and critical) and six components (obtain, understand, apply, interact, medial literacy and critical) of nutrition literacy (**Additional file 1: Supplementary Material S1**).

### Item Analysis Based On Ctt

Item analysis was conducted using CTT and the instrument included 14 items that did not meet the criteria. However, after the theoretical relevancy of nutrition literacy and the results of group discussion were combined, the final scale included 56 items (three items removed: Q7\_1.2.2, Q8\_1.2.3 and Q12\_1.2.7). Examples of changes made based on item analysis are shown in **Additional file 1: Supplementary Material S1**.

## Validity

#### Content validity

The mean value of CVI containing 56 items was 0.91, indicating good content validity. Group discussion, expert consultation, and the face validity results of the pilot study proved that most of the items in the questionnaire were suitable for middle school students.

#### EFA

The KMO test showed sampling adequacy = 0.916 and Bartlett's test confirmed that EFA was appropriate ( $\chi^2 = 5854.037, P < 0.001$ ). The percentage of the total variance was 69.438%, with six rotated factors. By the EFA results, acquired and understanding skills were combined in FNL and the following adjustments were made: 1) the following four application skill items were removed: 'Q31\_1.3.8 Frozen foods should not be thawed at room temperature', 'Q33\_1.3.10 Keep raw and cooked food separately', 'Q34\_1.3.11 Food should be heated through the second time' and 'Q39\_1.3.18 Regular meals'. 2) Three items from 'interactive skills' and 'critical skills' were changed to 'medial literacy (ML)', 'Q51\_2.1.6 Talk about nutrition with others (e.g. friends, family, etc.)', 'Q52\_2.1.7 Take the initiative to disseminate nutrition knowledge to others' and 'Q62\_3.2.4 Dare to question deeply rooted social and cultural phenomena related to food and health'. 3) Kept the item 'Q20\_1.2.15 It is easy to understand the contents of the Dietary Guidelines for Chinese residents'.

#### CFA

Significant correlations were found between items and factors in the first-order model ( $P < 0.001$ ). In the second-order model, except that the factor loading between application skills and FNL was not statistically significant ( $P = 0.123$ ), all the others were statistically significant ( $P < 0.001$ ). The results of the model fit for the CFA of scale are reported in Figs.2 and 3, which indicated a desirable fit of the proposed models.

**Figure 3. Second-order CFA analysis factor loading construct validity study for CM-NLS**

## Reliability

The Cronbach's alpha coefficient of the scale was tested for internal consistency. The results showed that the Cronbach's alpha coefficient of the total scale was 0.849, whilst that of the six subscales was 0.648–0.942, indicating that the reliability of internal consistency of the scale was well stable. The total scale split-half reliability coefficient was 0.521, whilst that of the six subscales was 0.509–0.914 (Table 2).

Table 2  
Cronbach's  $\alpha$  coefficient for the CM-NLS scale and its subscales

	Number of items	Scores	Mean	SD	Cronbach's $\alpha$	split-half reliability
<b>1.Functional NL</b>	<b>35</b>	<b>0–99</b>	<b>69.70</b>	<b>11.17</b>	<b>0.826</b>	<b>0.503</b>
1.1 Obtain	3	0–12	8.21	2.48	0.819	0.765
1.2 Understand	14	0–32	21.67	4.62	0.648	0.509
1.3 Apply/Use	18	0–55	39.81	7.10	0.778	0.724
<b>2.Interactive NL</b>	<b>5</b>	<b>0–20</b>	<b>5.46</b>	<b>3.75</b>	<b>0.942</b>	<b>0.914</b>
2.1 Interact	5	0–20	5.46	3.75	0.942	0.914
<b>3. Critical NL</b>	<b>12</b>	<b>0–48</b>	<b>27.07</b>	<b>10.39</b>	<b>0.938</b>	<b>0.860</b>
3.1 Medial literacy	8	0–32	17.37	7.85	0.938	0.901
3.2 Critical	4	0–16	9.71	3.57	0.909	0.906

## Discussion

This study was the first to report the validity and reliability of the assessment instrument to comprehensively evaluate the level of nutrition literacy of middle school students in Chongqing. Based on the conceptual models of health literacy illustrated by Nutbeam, nutrition literacy was divided into FNL, INL and CNL<sup>20</sup>. After a two-round Delphi survey, the items of the nutrition literacy scale of middle schoolers in Chongqing were finally determined, including three primary indicators, six sub-indicators and 52 items. The results of the research confirmed the reliability and validity of CM-NLS, including content and structure.

The expert group had a high degree of agreement on the highest score for FNL. Other researchers also believed that functional literacy is the basis of interactive and critical literacy<sup>27</sup>. FNL is important for middle schoolers to acquire nutrition knowledge and develop healthy dietary habits. Besides, middle schoolers should take the initiative to obtain and understand nutrition information, such as understanding the whole process of food from farm to table (production, processing, transportation, purchase and handling). A notable detail that the authors agreed with Thomas et al., who revealed that nutrition literacy should also emphasize the importance of practice in nutritional information<sup>26, 46</sup>. However, the practical ability of middle school students in China was insufficient; they were relatively weak in practical skills, such as food purchasing and food cooking<sup>47, 48</sup>. Therefore, the 'application skills' mainly emphasized dietary behavior whilst ignoring the importance of students' application of nutrition information. This problem should be given attention in the future. In addition, the INL score was high. According to the results of the pilot study, middle school students mostly obtained information from families and teachers; it was a one-sided communication between teachers and parents to students, leading to the lack of initiative of students to interact with others. Although the CNL score was the lowest amongst the three subscales, the students' media literacy and critical skills are still necessary to understand. In recent years, adolescents have increasing access to nutrition information<sup>49</sup>, which may lead to information misunderstanding and confusion<sup>50</sup>. Wadsworth advocated that media literacy (the ability to critically view and understand information) should be included in diet-related education<sup>51</sup>. In the framework concept, media literacy and critical skills were placed in the section of CNL, which made up for the deficiency that only a few researchers had explored<sup>16</sup>.

After CTT and structural analysis, some items differing from the results of expert consultation and the purpose of the research were deleted or adjusted. For instance, the item 'It is easy to understand the contents of the Dietary Guidelines for Chinese Residents' was deleted. This deletion could imply that the Dietary Guidelines for Chinese Residents was difficult to understand for middle school students with lacking professional guidance to understand<sup>24</sup>. The CFA results showed that except for the *P*-value, GFI and AGFI were close to 0.9, whilst other data met the requirements. This finding may be influenced by the sample size; the chi-square value of the model was very sensitive to the sample size and the larger the sample size was, the more likely it was to reach a significant value<sup>52, 53</sup>. The EFA and CFA results showed a poor correlation between application skills and the other five dimensions. The application skills should not belong to FNL and be contrary to the judgment of professional knowledge. This finding could be interpreted as three factors at interplay in obtaining the results. Firstly, according to Bloom's taxonomy (revised), the six levels of cognitive learning are remembering, understanding, applying, analyzing, evaluating and creating<sup>54</sup>. The cognitive development of middle school students may not be advanced enough to 'apply' the skills<sup>55</sup>. Secondly, the application skills may have some regional differences in the real world; the original literature and guidelines focused on adolescents across China but Chongqing is a multi-ethnic area<sup>56</sup>. Finally, the Chinese education system places more emphasis on rote learning and silent learning rather than application, leading to the original hypothesis not being verified<sup>57</sup>. The Cronbach's alpha value of the screened scale was 0.851; the values of the other items were between 0.648 and 0.942 and the mean value of CVI containing 56 items was 0.91, indicating that CM-NLS was consistent with the theoretical framework and had reasonable reliability and validity.

This study is based on literature research. A total of 18 experts were consulted in strict accordance with the Delphi method. The results combined subjective assessment with objective analysis. Furthermore, CTT and validity tests were used to screen the items and the relationship amongst theory, experience and

data in scale design was well-handled<sup>31</sup>. However, the study still has several limitations. Firstly, the sample size was not representative of the entire population. As CM-NLS only included students from one school, it still needs to be applied to a larger population to verify its feasibility and validity. Besides, due to the COVID-19 epidemic situation, the preliminary survey of this study was mainly conducted online, and some information bias may be present in the self-report of students. Furthermore, the design of nutrition literacy assessment instruments is dynamic and needs to be modified and improved under the updated guidelines and literature.

## Conclusions

Overall, CM-NLS is a valid and reliable instrument to measure nutrition literacy amongst middle school students in Chongqing. It could be used to identify key problems, such as nutrition education intervention, and pertinence measures to education. It could also provide a scientific basis for the implementation of nutrition education strategies. Considering that nutrition literacy is dynamic, more samples are needed to modify, optimize and apply the scale based on the actual situation in the future.

## Abbreviations

AGFI  
adjusted goodness of fit index  
CFA  
confirmatory factor analysis  
CM-NLS  
Chongqing Middle school student Nutrition Literacy Scale  
CNL  
critical nutrition literacy  
CTT  
Classical Test Theory  
CVI  
content validity index  
EFA  
exploratory factor analysis  
FNL  
functional nutrition literacy  
GFI  
goodness-of-fit index  
INL  
interactive nutrition literacy  
KMO  
Kaiser–Meyer–Olkin  
RMSEA  
root mean square error of approximation

## Declarations

### Ethical Approval and Consent to participate

The study was presented to the Ethics Committee of Chongqing Medical University. All participants were informed about the study and provide informed consent before participation in the Delphi expert consultation and pilot study.

### Consent for publication

Not applicable.

### Authors' agreements

This manuscript has not been published elsewhere. This manuscript has not and will not be submitted for publication elsewhere until a decision is made regarding its acceptability by your journal. If accepted for publication, it will not be published elsewhere. All authors have contributed substantially to the manuscript and approved final submission. All authors accept full responsibility for all aspects of the work described.

### Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon request.

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## Competing interests

The authors declare that they have no competing interests.

## Authors' contributions

TW and MZ contributes equally to this work. TW, MZ, and YZ jointly conceptualized the study. MZ and YZ were involved in data extraction and verification of the extracted data. TW and MZ worked on the first draft of the manuscript, CX, YZ and MS provided guidance and suggested revisions. TW and MZ amended the second draft of the manuscript. YZ provided critical updates to the final manuscript. All authors read and approved the final manuscript.

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## Figures

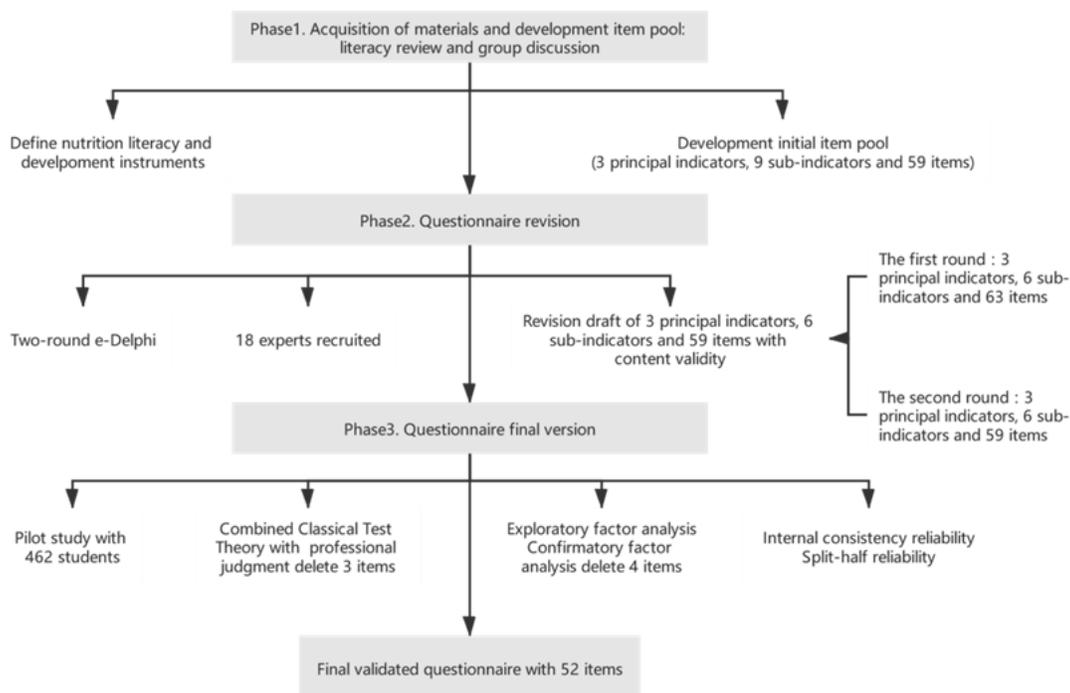


Figure 1

Flow chart of the scale development procedure

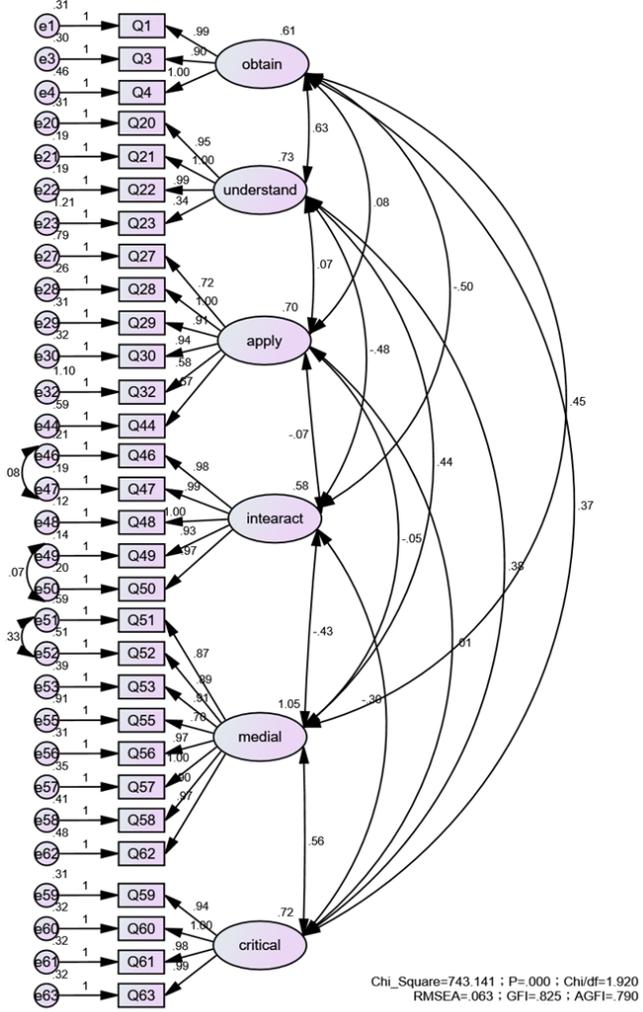


Figure 2

First-order CFA analysis factor loading construct validity study for CM-NLS

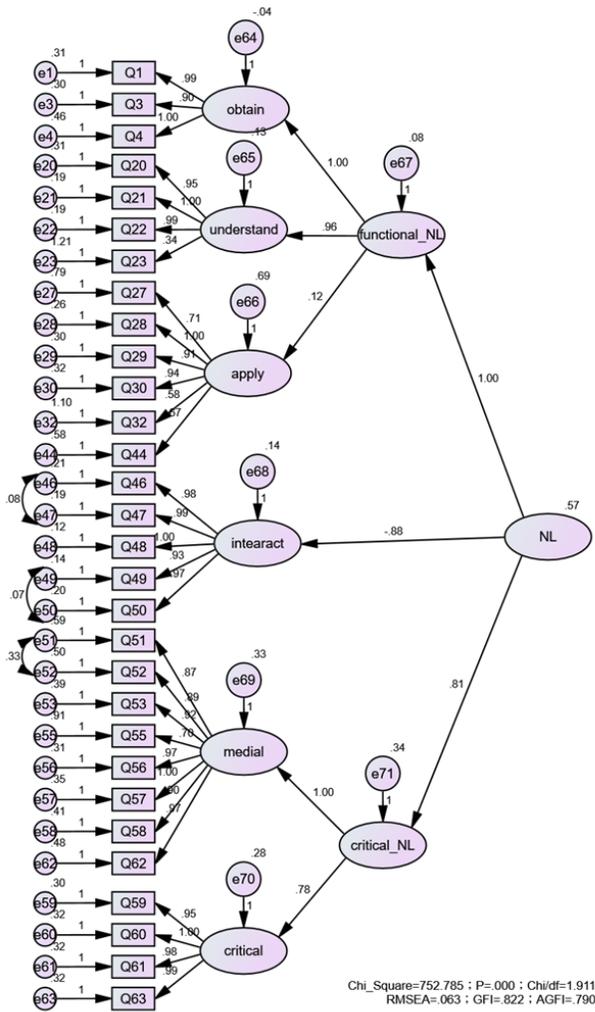


Figure 3

Second-order CFA analysis factor loading construct validity study for CM-NLS

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