Original Article

# Development and Validation of Food and Nutrition Literacy Assessment Tool for Iranian High-school Graduates and Youth

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## Abstract

**Background:** Food and nutrition literacy (FNL) is an emerging concept that emphasizes not only on personal knowledge, but food and nutrition skills about. This study aimed to develop and validate a food and nutrition literacy assessment tool (FNLAT) for youth and high-school graduates in Iran. **Methods:** The study protocol included the following steps: First, FNL components for Iranian high-school graduates and youth were identified through literature review and interviews with experts. Delphi method was used in order to achieve consensus about FNL components. Then, the questionnaire items were generated, and its content and face validity were assessed. Construct validity of the questionnaire was evaluated through applying principal component analysis (PCA) and confirmatory factor analyses (CFA) in the next step. Finally, reliability of the FNLAT was assessed by calculating Cronbach's Alpha and evaluating test-retest reliability. **Results:** A 104-item questionnaire was developed. S-CVI was ≥90 which confirmed content validity of the questionnaire. PCA suggested that it was constructed of 6 factors, one in knowledge domain (food and nutrition knowledge) and five in skill domain (functional skills, interactive skills, advocacy, critical analysis of information, and food label reading skills). On the basis of CFA, the fit indices of the model had acceptable fit and confirmed construct validity of the FNLAT ($X^2$/df = 1.58, RMSEA = 0.041; $P$ = 1.00, RMR = 0.034, GFI = 0.79). The values of Cronbach's Alpha and intraclass correlation coefficient (ICC) confirmed internal consistency and time stability of the FNLAT and its subscales. **Conclusions:** The developed FNLAT is a valid and reliable tool to assess FNL in Iranian late adolescents and youth.

**Keywords:** *Literacy, nutrition, validation study, young adults*

## Introduction

A body of evidence indicate that poor diet quality and unhealthy eating habits are among the leading risk factors for chronic diseases, including obesity, diabetes, cardiovascular diseases and some types of cancers.[1] The estimated cost of healthcare resulted from obesity and nutrition related chronic diseases has been reported to range from three to 72 billion dollars in developing countries.[2] Therefore, improving eating behaviors has been considered as one the main strategies to reduce prevalence of non-communicable diseases in both the developed and developing countries.[1]

Despite the profound role of social and environmental factors in predicting eating behaviors,[3] personal self-care capabilities, i.e., knowledge and skills, also substantially determine people's dietary practices.[4-6]The complexity of the foods available in the marketplace makes it hard to select foods wisely and this requires nutritionally literate consumers. "Food literacy" and "nutrition literacy" are emerging concepts which emphasize on the personal knowledge and skills about food and nutrition. Food 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".[7] A suggested definition for nutrition literacy derived from the health literacy definition is "the degree to which people have the capacity to obtain, process, and understand basic nutrition information".[8] These concepts have a fundamental overlaps and complementarities, and aimed to the same goal, that is, promoting sustainable and healthy food choice. Therefore, we use the term "food and nutrition literacy" (FNL) as a more comprehensive phrase to describe the set of knowledge and skills which



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enable people to "make appropriate nutrition decisions"[8] and "plan, manage, select, prepare, and eat foods".[7]

While improving food and nutrition literacy (FNL) status of population has been considered by planners and policymakers as an effective approach to increase diet quality,[9-12] its operational definition and measurement is still a challenge. Therefore, most of the works in this area have been focused on defining the concept of food and nutrition literacy and exploring its dimensions and components in different communities.[7,13-18]

Defining the FNL concept and developing valid assessment tools are fundamental steps in the FNL evolution path to evaluate FNL status of populations and come up with proper strategies for its promotion and improvement. The available tools designed to assess food and nutrition literacy have several limitations to be used in the context of the present study.[19-23] In some of these instruments, all assumed dimensions of FNL [functional, interactive, and critical) have not been addressed,[19,21,23] or the included set of knowledge and skills do not cover all identified components of FNL.[19-23] For example, environmental sustainability and advocacy for promoting healthy eating are important aspects that are missing in most of available tools.[19-23] After all, the dimensions and components of food and nutrition literacy are relatively context specific; consequently, a tool aimed to assess FNL must also be developed with regard to the community context. For instance, the results of studies conducted by the same research team in Iran and Australia have shown that identified component of nutrition and food systems knowledge based on each country's experts' opinions differ in some aspects.[24,25] Doust Mohammadian *et al*. have recently developed and validated a questionnaire to assess FNL of primary school-age children (aged 10 – 12 years) in Iran.[26] However, the level of knowledge and skills included in the questionnaire may not be appropriate for late adolescents and youth. Therefore, this study was conducted to develop and validate a food and nutrition literacy assessment tool (FNLAT) for high-school graduates and young adults in Iran.

## Methods

The theoretical framework developed for this study was inspired by Nutbeam's hierarchical model of health literacy.[27] On the basis of his proposed model, nutrition literacy could be defined with three distinct components, including functional, interactive and critical.[27] Functional FNL refers to basic food and nutrition related skills by which people can function effectively in everyday situations. Interactive FNL includes more advance cognitive and interpersonal communication skills. It also could include an interest in seeking and applying food and nutrition information. Finally, at the highest level, critical FNL refers to both the ability to analyze information critically and to be motivated enough to participate in voluntary activities aimed at improving food and nutritional health in family, community or even population levels.[28,29]

This study was designed in 5 steps [Figure 1]: (1) Identification of food and nutrition literacy (FNL) components for high school graduates and youth; (2) Item generation and drafting the questionnaire; (3) Assessment of content and face validity; (4) Assessment of construct validity; and (5) Assessment of reliability of the developed questionnaire.

1. Identification of food and nutrition literacy components. The domains and components of food and nutrition literacy were identified through literature review, as well as an expert panel approach. The literature review was carried out using the following keywords to search available literature in Google scholar from 1990 until April 2017: "food literacy", "nutrition literacy", "food skill", "food practice", "food preparation", and "nutrition skill". Also, an expert panel approach was applied in two steps to explore additional FNL components which may be context specific for Iranian population. In this regard, six semi-structured, in-depth interviews were performed with the experts in the fields of food, nutrition and health education. The results of literature review and interviews were merged and key dimensions and potential components of FNL were extracted. To do so, data were coded by two researchers, independently. Thematic analysis and constant comparative method were applied to extract main themes and sub-themes.
   In the second step, in order to reach a consensus about the FNL components, Delphi method was applied. A total of 19 Iranian experts from relevant fields were invited, of whom 17 (1 health education, 1 food industry specialist, 14 nutritionists, and 1 sociologist) accepted to participate. In each Delphi round, participants were asked to identify the main FNL components for Iranian high-school graduates. Consensus was defined as agreement of at least 70% of expert panel for inclusion of a component as necessary; and agreement of at least 50% of expert panel for exclusion of a component. Components for which did not obtain minimum agreement level for inclusion or exclusion were taken to the next round. Three Delphi rounds were held to reach consensus.
2) Item generation. On the basis of FNL components identified through the Delphi rounds, a list of 86 items for assessing dimensions of FNL was developed. In addition, after reviewing existing tools,[22,23] 18 additional items from interactive and critical constructs of nutrition literacy questionnaire developed and validated by Ndahura *et al*.[22] were translated and added to the questionnaire (after getting author's permission). To examine whether these translated items capture the same concept as the English version; they were back translated to English by an independent translator and sent to the main researcher. Once they confirmed the translation process, the items were adopted.

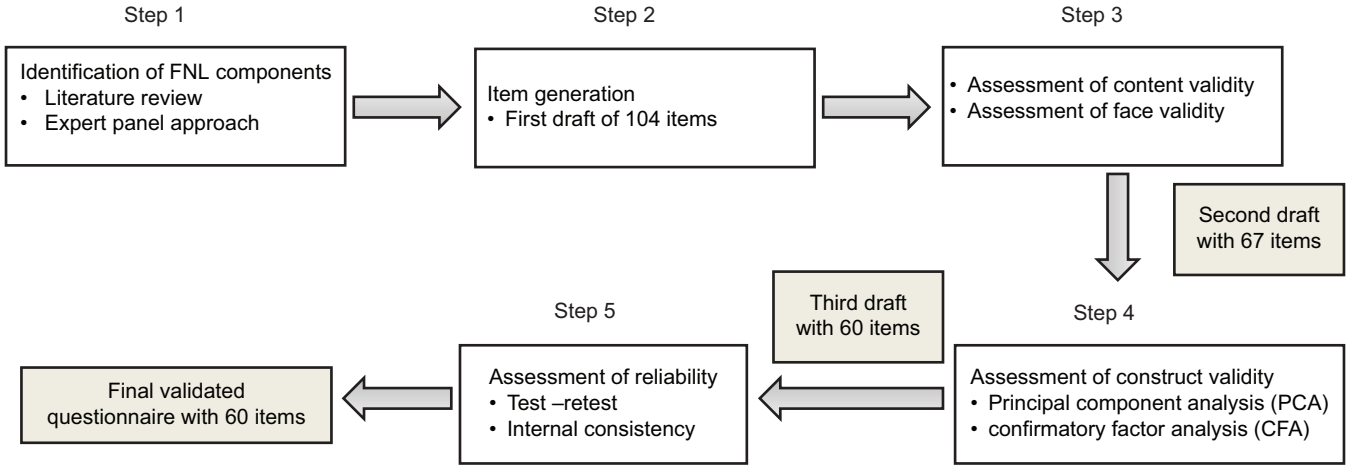


**Figure 1: Summary of steps fallowed in the development of FNLAT**

3) Assessment of content and face validity. In order to evaluate content of the developed questionnaire, a panel of 8 experts from different relevant fields (4 nutritionists, 1 food technology specialist, 2 health education specialists and 1 sociologist) examined it qualitatively (wording, clarity, scoring) and quantitatively (Content Validity Index (CVI)). Based on their comments, required changes were made. The CVI for the whole scale (S-CVI) and for each item (I-CVI) were calculated.[30] In order to calculate I-CVI, the experts were asked about content relevance of each item using a 4-point scale (1: extremely relevant and 4: extremely irrelevant). Minimum acceptable values of I-CVI (the proportion of experts who rate an item as extremely relevant or moderately relevant), for a panel of 8 and 7 experts are 0.875 and 0.857, respectively[30] (some experts did not rate a couple of items, so 0.857 was considered acceptable for items which was rated by7 experts). S-CVI was calculated by two methods (based on two different definitions). In one definition, S-CVI is "the proportion of items which were judged content valid" and the other is "the average of I-CVIs for all items in the scale".[30,31]Acceptable values for these methods are 0.8 and 0.9, respectively.[30,31]
   Also, face validity of FNLAT was evaluated by10 senior high school students (5 girls and 5 boys) who did not take part in the main study. They were interviewed about wording, clarity and degree of complexity of questions and statements.
4) Assessment of construct validity. Principal component analysis (PCA) and confirmatory factor analysis (CFA) were performed to confirm construct validity of the scale. A total of 697 senior high-school students were randomly recruited from high schools in three different socio-economic districts of Tehran. Data collection was carried out between November 2017 and April 2018. After obtaining written informed consent from students and their parents, FNL questionnaire was completed by the students. The first half of the collected data (349 cases) was applied to conduct PCA. Using the other half of data (348 cases), CFA was performed to assess whether the model generated through PCA, fits this data set.
5) Assessment of reliability. Testretest reliability and internal consistency were applied to assess reliability of the questionnaire. To conduct test-retest reliability, 28 students (15 girls and 13 boys) in the last year of high-school completed the questionnaire twice, with one-month interval. Internal consistency of the questionnaire was examined by calculating Cronbach's Alpha.

Statistical analysis: Principal component analysis (PCA) was used to identify the underlying constructs of the questionnaire. In PCA, principal components extraction method and Varimax rotation were applied. Required sample size for PCA was estimated based on the minimum acceptable subject to item ratio of 5:1.[32] Adequacy of sample size was measured using KaiserMeyerOlkin (KMO). Bartlett's Test of Sphericity was used for the evaluation of the factor model. Four criteria were applied to determine the number of extracted factor through PCA, including Eigen values, percentage of explained variance by each factor, scree plot and interpretability. CFA was performed using IBM SPSS Amos software (version 21). Goodness-of-fit index (GFI), root mean square error of approximation (RMSEA), $X^2$/df, and Standardized Root mean squared residual (SRMR) were used to examine fitness of the suggested model.FGI >0.9, RMSEA <0.08, $X^2$/df <5, and SRMR <0.08 are acceptable.[33] ICC was calculated to examine test-retest reliability. Time stability of the dimensions which are consisted of binary items was assessed by calculating Pearson correlation coefficient between the score of these dimensions measured in time 1 and time 2. Cronbach's Alpha was calculated to test internal consistency of each subscale and the whole questionnaire (first half of the dataset was used to calculate Cronbach's Alpha). Also, KuderRichardson (KR20)

coefficient was calculated for binary items. The minimum acceptable values for Cronbach's Alpha (or KR20 coefficient) and ICC were considered 0.7 and 0.8, respectively.[34,35] All statistical analyses (except for CFA) were performed using SPSS 21.0 (SPSS Inc., Chicago, Illinois, U.S.).

Ethical considerations: The study protocol received ethical approval of National Nutrition and Food Technology Research Institute (NNFTRI) ethical committee (IR.SBMU.nnftri.Rec. 1396.166). Written informed consent was obtained from students and their parents.

## Results

Through analysis of recorded interviews and existing literature,[7,13,15,17,18,23,24,36] 42 and 82 codes were extracted, respectively. After merging list of the codes from two sources of data and excluding the duplicates, 104 codes remained as the potential components of FNL. The latter list was evaluated by a panel of experts through a three rounds Delphi study. Out of 104 codes, 88 were endorsed by >70% of the Delphi panelists to be considered as the final components of FNL. Through thematic analysis, two main domains, including "knowledge" and "skill" were identified. In the skill domain, in line with Nutbeam's hierarchical model of health literacy,[27] 3 levels of skills were identified, including functional, interactive and critical skills. Final domains, dimensions and sub-dimensions of FNL are shown in Figure 2.

As the first step of the questionnaire development, 104 items, including questions and statements were developed based on the two identified dimensions. These items included46 binary questions for assessing food and nutrition knowledge and food label reading skills; and 58 Likert-type statements for assessing skill domain.

Through content validation and after applying the comments of the experts about wording, clarity, scoring, and necessity of items, 29 items were omitted from the primary list. I-CVI was calculated for the remaining items (75 items). Seven additional items did not obtain minimum acceptable values for I-CVI, of which 5 items were deleted and 2 were revised. As explained before, S-CVI was calculated by two methods. Based on the first definition (*i.e.,* the proportion of items which were judged content valid,) S-CVI was 0.90.Calculation of S-CVI by the second method (the average of I-CVIs for all items in the scale) was about the same, as shown below:

$$\text{S-CVI} = \frac{(44\times1)+(20\times0.875)+(4\times0.857)+(7\times0.75)}{75} = 0.935$$

Both values confirmed content validity of the FNLAT.

Face validity assessment indicated that most of the items could be read and understood by the target group easily. However, minor changes were made in some statements based on students' feedback. Only 3 items were omitted, two due to their simplicity as expressed by the students and one because it was misunderstood [Table 1]. After all, a 67-item questionnaire was accepted to be evaluated through the construct validity process.

In order to evaluate construct validity, a sample of 697 senior high school students (17-18 years old) completed

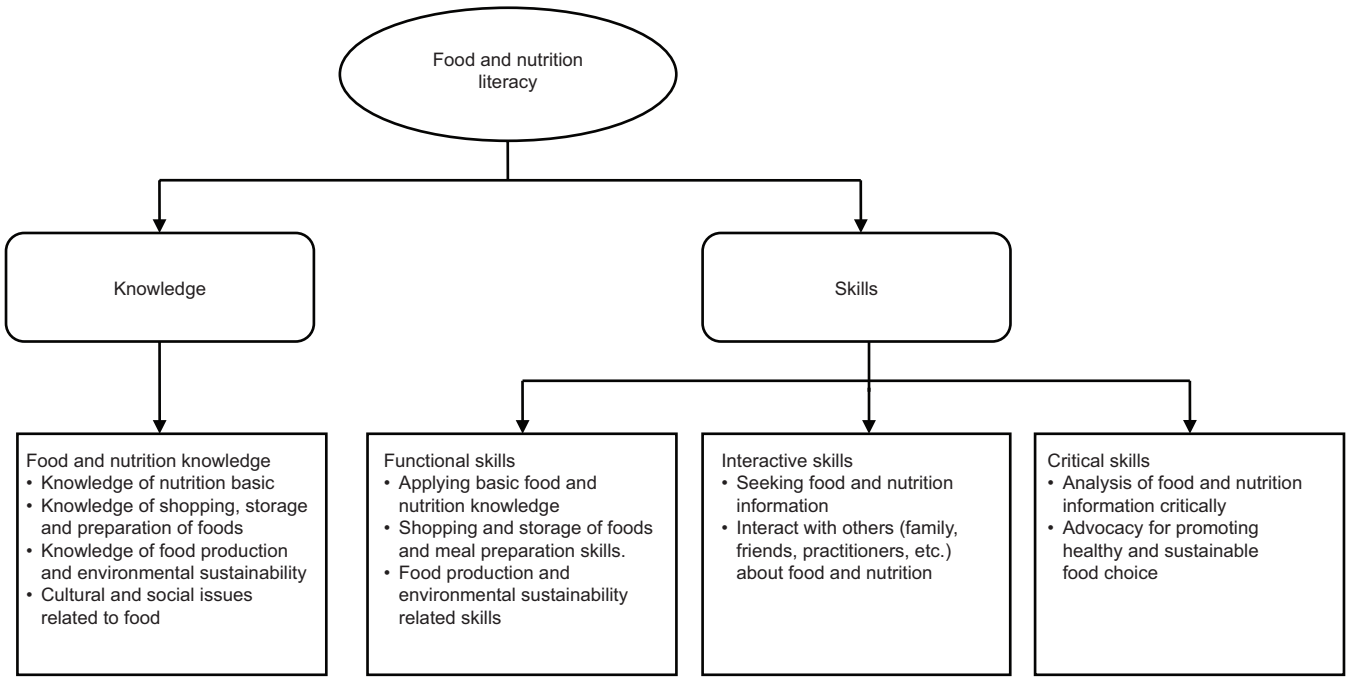


**Figure 2: Identified domains, dimensions and sub-dimensions of FNL for Iranian high-school graduates and youth**

the questionnaire. The distribution of study participants by gender and the district of their high school, as well as their study major are shown in Table 2.

PCA was performed for the "Knowledge" and "Skill" domains, separately. The adequacy of sample size for conducting PCA ($N$ = 349) was confirmed in both domains, as the KaiserMeyer-Olkin (KMO) was greater than 0.6 [Table 3]. The Bartlett's Test of Sphericity also indicated that the factor models were appropriate ($P < 0.001$) [Tables 3 and 4].

In the "knowledge" domain, considering the scree plot (which showed a drop after the first factor [Appendix I] and other criteria (percentage of explained variance and interpretability), one factor was retained. Low factor loading (lower than 0.2) for item 16 and 18 [Appendix II] indicated that omitting them can improve construct validity of knowledge domain. Therefore, PCA was repeated with 27 items [Table 3].

In the "skill" domain, PCA suggested a five-factor construct [Appendix I] which explained 40.75% of total variance. On the basis of the loaded items on each factor and the theoretical assumption of the study, these factors were labeled as "functional skills", "interactive skills", "advocacy", "critical analysis of information" and "food label reading skills"[Table 4]. When all items were interred in primary model, limited number of items, including items 30, 34, 49, and 62 loaded on factors with which they were not fit theoretically [Appendix III]. Item 48 also had negative factor loading in factor it had been designated for and the Cronbach's "Alpha if item deleted" showed that deleting it could increase the Cronbach's Alpha [Appendix III]. As the omission of these items (*i.e.,* items 30, 34, 49, 62, and 48) was justifiable for the research team, PCA was run again without these items [Table 4]. In the final model, almost all items loaded on expected factors. However, two items (33 and 53) had relatively high factor loading in the expected factors (*i.e.,* "functional skills" and "advocacy", respectively), as well as in another factor (i.e., "food label reading skills" and "interactive skills", respectively). As, theoretically these items could not be included in the factors in which their factor loading was the highest, the research team decided to keep them in the constructs they had been designated for.

Finally, the FNL model was evaluated through CFA [Figure 3]. As shown in the figure, standardized regression weights ranged from 0.19 to 0.82 in the skill domain and from 0.11 to 0.47 in the knowledge domain. In the skill domain, interactive skills had the highest (0.92) regression weight and food label reading skills the lowest (0.24). All regression weights were statistically significant ($P < 0.05$), except for knowledge domain. The fit indices of the model showed acceptable fit and confirmed construct validity of the FNLAT ($X^2/df$ = 1.58, RMSEA = 0.041; $P$ = 1.00, RMR = 0.034, GFI = 0.79).

To test internal consistency of the scales within the questionnaire, Cronbach's Alpha was calculated for each dimension [Appendix II and Appendix III]. It was shown that omission of items 16, 18, 30, 48, 49, and 62 would increase the Alpha of the corresponding dimension [AppendixII and Appendix III]. The results of reliability analysis provided further support for removing these items from final model of "Skill" and "knowledge" domains. The percentage of explained variance, and

**Table 1: Items deleted through face validation step**

| Items | Reason of omission |
|---|---|
| Eating fast food frequently can cause obesity and some chronic diseases such as diabetes, cancer and coronary heart disease. | Perceived too simple |
| (a) True (b) False (c) I don't know | |
| Uncontrolled diabetes could lead to Kidney failure. | Perceived too simple |
| (a) True (b) False (c) I don't know | |
| Which of the following option have higher nutrition value? | Misunderstood |
| (a) Smaller apples (b) larger apples (c) It is not different (d) I don't know | |

**Table 2: Demographic characteristics of students participated in the construct validity study**

| | PCA sample ($n$=349) $n$ (%) | CFA sample ($n$=338) $n$ (%) | Total ($n$=697) $n$ (%) |
|---|---|---|---|
| Gender | | | |
| Male | 154 (44.1) | 184 (52.9) | 338 (48.5) |
| Female | 195 (55.9) | 164 (47.1) | 359 (51.5) |
| City districts | | | |
| High SES (districts 2,4,5) | 198 (56.7) | 166 (47.7) | 364 (52.2) |
| Middle SES (districts 9, 11, 14) | 60 (17.2) | 112 (32.2) | 172 (24.7) |
| Low SES (districts 15, 16, 17) | 91 (26.1) | 70 (20.1) | 161 (23.1) |
| Study major | | | |
| Biological Sciences | 124 (35.5) | 121 (34.8) | 245 (35.2) |
| Mathematics | 135 (38.7) | 151 (43.4) | 286 (41) |
| Literature and Humanities | 90 (25.8) | 76 (21.8) | 166 (23.8) |

SES: Socio-economic status

**Table 3:Factor loadings and α if item deleted for each item in knowledge domain after deletion of item 16 and 18**

| Items | Factor Loading | Cronbach's α if item deleted |
|---|---|---|
| 1. A balanced meal plan is a plan in which appropriate amounts of each food group is used. | 0.325 | 0.737 |
| 2. Which of the following foods is not included in dairy food group? | 0.323 | 0.736 |
| 3. Which of the following options is equal to one serving of grains food group? | 0.345 | 0.735 |
| 4. Which of the following nutrients are mainly provided by meat group? | 0.298 | 0.738 |
| 5. During pregnancy, how does daily requirement of meat (white and red meat) consumption change? | 0.263 | 0.739 |
| 6. Legumes are not the good sources of proteins. | 0.345 | 0.735 |
| 7. Which of the following foods are good sources of Calcium? | 0.203 | 0.741 |
| 8. Which of the following nutrients do provide energy to our body? | 0.542 | 0.724 |
| 9. Red meat, poultry and eggs are good sources of ……. | 0.399 | 0.734 |
| 10. Trans fatty acids are fatty acids which …… | 0.546 | 0.723 |
| 11.Which of the followings is the best time to add iodized salt to food? | 0.327 | 0.737 |
| 12. Obesity and being overweight during young age is not associated with diabetes in older ages. | 0.462 | 0.728 |
| 13. Osteoporosis occurs as people grow older and cannot be prevented. | 0.372 | 0.736 |
| 14. If you don't have enough money to buy meat, which of following foods will be a more appropriate alternative? | 0.271 | 0.739 |
| 15. Which of the following cuts of meat has more fat? | 0.309 | 0.737 |
| 17. Red raw meat can be kept in the fridge for one week. | 0.300 | 0.738 |
| 19. In which of the following cooking methods, nutritional values of vegetables are better maintained? | 0.460 | 0.729 |
| 20. Production of 1 kilogram wheat requires more water than production of 1 kilogram of red meat (beef). | 0.264 | 0.738 |
| 21. The difference between pasteurized and sterilized milks is in heating method and the temperature used. | 0.300 | 0.738 |
| 22. Consumption of animal foods harms the environment less than plant foods. | 0.397 | 0.733 |
| 23. Using food products which are produced locally can help environmental sustainability. | 0.224 | 0.741 |
| 24. Global warming could affect people's access to adequate and healthy foods. | 0.500 | 0.727 |
| 25. Production of plant foods compared with animal foods results in equal amount of greenhouse gas emission. | 0.407 | 0.732 |
| 26. Imagine you enter a supermarket to choose a healthy snack, which of the following snacks is the healthiest choice? | 0.389 | 0.733 |
| 27. If you are asked to choose the healthiest among the followings to prepare a food, which one will you select? | 0.355 | 0.736 |
| 28.Body mass index (BMI) of a person who weighs 64 Kg and is 170 cm tall equals to: | 0.314 | 0.738 |
| 29. An adult person has a BMI of 27; How do you evaluate his weight status? He/she is | 0.425 | 0.733 |

Kaiser-Meyer-Olkin (KMO) was 0.728. *P* value for Bartlett's Test of Sphericity was <0.001 ($\chi^2$=1011.33, Degree of freedom=351)

Cronbach's Alpha for all dimensions of the FNLAT are shown in the Table 5. Cronbach's Alpha was more than 0.7 for the whole questionnaire and most of the dimensions/ sub-scales. However, in two dimensions, including "critical analysis of information" and "food label reading skills", it was less than the minimum acceptable value.

ICC/Pearson coefficients for each dimension and for the whole questionnaire are shown in the Table 5. As demonstrated, the values of Spearman-brown coefficient for most of the dimensions and for the whole questionnaire meet the acceptable value (except for "critical analysis of information") confirming time stability of FNLAT. The value of Pearson coefficient for "Knowledge" and "food label reading skills" dimensions showed acceptable correlation between the scores of time 1 and time 2.

## Discussion

The findings showed that FNLAT is valid and reliable to evaluate FNL status of Iranian high school graduates and young adults. The questionnaire design was based on Nutbeam framework of health literacy[27] which proposes three levels of functional, interactive and critical skills for assessment of health related literacy. This approach which is based on deep learning concept of pedagogical theories,[27] takes into account interpersonal, social and environmental consequences of FNL. A major part of the present questionnaire includes skill domain items comprised of the three components, in line with the theoretical assumption. However, based on PCA, other components were also identified that can help in gaining a deeper understanding of dimensions of FNL. One of the identified sub-domains was food label literacy. Food label literacy has been used as a subscale in some FNL assessment tools,[26] while a number of other available tools do not necessarily include food label reading and interpreting skills as one of their components.[20,22]

With regard to critical dimension of FNL, two types of skills have been addressed in the literature.[28,36] First, those skills which enable people to appraise food and nutrition information critically and to judge the authenticity of different sources of information. Second, the capacity for taking social actions to address barriers to healthy and sustainable food choices.[28,36] In the present study, although both of these competencies were considered as dimensions

**Table 4:Factor loadings and α if item deleted for each item in dimensions of Skill domain after deletion of item 30, 34, 48, 49, and 62**

| Items | Functional skills | Interactive skills | Advocacy | Critical analysis of information | Food label reading skills | Cronbach's α if item deleted |
|---|---|---|---|---|---|---|
| 31. When buying meat, I can recognize its freshness and quality by Checking the appearance. | **0.484** | 0.072 | 0.140 | 0.132 | 0.212 | 0.813 |
| 32. If I have to eat fast Foods (due to lack of time or cooking facilities), I can choose the healthier one. | **0.342** | 0.137 | 0.224 | 0.053 | 0.350 | 0.819 |
| 33. I can buy groceries as much as I need, so that they do not get spoiled or wasted. | **0.296** | 0.090 | 0.076 | 0.061 | 0.414 | 0.824 |
| 35. I am familiar with the basic skills of cooking (e.g. sautéing, frying, stewing rice, using salt and spices, etc.) | **0.802** | 0.051 | 0.041 | 0.028 | 0.043 | 0.799 |
| 36. I know how to preserve foods through using methods such as drying or freezing. | **0.677** | 0.137 | 0.145 | 0.005 | 0.139 | 0.800 |
| 37. I can prepare tasty and healthy foods that me and my family like it. | **0.799** | 0.155 | 0.089 | 0.014 | 0.007 | 0.793 |
| 38. I easily can use cooking equipmentsuch as pressure cooker, stove, and oven. | **0.721** | 0.011 | 0.060 | 0.003 | 0.152 | 0.802 |
| 39. If some ingredients of a recipe are not available, I can change the recipe according to available ingredients. | **0.736** | 0.254 | 0.080 | 0.035 | 0.109 | 0.801 |
| 40. I can make yoghurt from milk. | **0.508** | 0.097 | 0.063 | 0.086 | 0.068 | 0.820 |
| 41. Have you ever experienced planting vegetables (e.g. basil, parsley or tomatoes) in the garden or pots? | **0.485** | 0.108 | 0.009 | 0.069 | 0.073 | 0.819 |
| 42. I can separate dry and wet food disposals. | **0.371** | 0.040 | 0.190 | 0.128 | 0.172 | 0.825 |
| 43. I have collected the nutritional information useful to me from different sources. | 0.224 | **0.668** | 0.128 | 0.022 | 0.146 | 0.644 |
| 44. I use the internet when I am searching information about diet and nutrition. | 0.047 | **0.452** | 0.142 | 0.114 | 0.097 | 0.720 |
| 45. I have changed my food habits based on the information I have got about nutrition. | 0.120 | **0.670** | 0.126 | 0.088 | 0.219 | 0.653 |
| 46. I usually follow TV or radio talk shows on nutrition. | 0.096 | **0.556** | 0.135 | 0.167 | 0.069 | 0.693 |
| 47. I follow information on characteristics of a balanced diet. | 0.141 | **0.643** | 0.140 | 0.209 | 0.128 | 0.656 |
| 50. I discuss my thoughts about diet with others (including family, friends, and doctors). | 0.124 | **0.556** | 0.195 | 0.013 | 0.027 | 0.679 |
| 51. If I go to grocery stores independently, I can easily ask the seller for the information I need. | 0.135 | **0.263** | 0.270 | 0.041 | 0.233 | 0.718 |
| 52. I can easily get involved in political discussion aiming at improving nutritional status of Iranian people. | 0.179 | 0.347 | **0.379** | 0.119 | 0.113 | 0.765 |
| 53. I am interested in taking an active role in activities aiming at promoting healthy diet. | 0.147 | 0.522 | **0.417** | 0.202 | -0.005 | 0.743 |
| 54. I expect my school or work place to serve healthy foods. | 0.075 | -0.053 | **0.730** | 0.006 | 0.263 | 0.751 |
| 55. I try to convince others (e.g., my family or friends) to eat healthy foods. | 0.069 | 0.402 | **0.600** | 0.027 | 0.085 | 0.738 |
| 56. It's important for me various healthy foods to be available to choose in the school canteen. | 0.050 | 0.025 | **0.788** | 0.099 | 0.146 | 0.737 |
| 63 I am an environmentalist and willing to voluntarily work toward supporting Eco-friendly methods of food production. | 0.185 | 0.133 | **0.537** | 0.133 | 0.118 | 0.751 |
| 64. I am interested in voluntary activities to reduce unhealthy snacks and fast food availability in my neighborhood, school or workplace. | 0.180 | 0.256 | **0.624** | 0.068 | 0.185 | 0.727 |
| 57. I am usually influenced by nutritional recommendation made by my family and friends. | 0.036 | 0.278 | -0.305 | **0.378** | 0.121 | 0.609 |
| 58. I trust different diets that I read about in newspapers and magazines. | 0.019 | 0.203 | -0.099 | **0.750** | 0.008 | 0.521 |

*Contd...*

**Table 4:Contd...**

| Items | Functional skills | Interactive skills | Advocacy | Critical analysis of information | Food label reading skills | Cronbach's α if item deleted |
|---|---|---|---|---|---|---|
| 59. I believe that the scientific findings on nutrition, food and diet discussed in mass media are correct. | -0.056 | 0.243 | -0.051 | **0.666** | 0.124 | 0.551 |
| 60. It's difficult for me to distinguish between scientific and non-scientific materials about diet. | 0.138 | 0.108 | -0.003 | **0.473** | 0.032 | 0.648 |
| 61. The claims advertised by food manufacturers about the positive health effects of their food products are reliable. | 0.096 | 0.031 | 0.046 | **0.666** | 0.131 | 0.606 |
| 65. If you eat a package of cheese with the following label information, how much calories you will get from this product? | 0.007 | 0.177 | 0.043 | 0.198 | **0.469** | 0.614 |
| 66. Considering food labels of product 1 and product 2, which one is more appropriate for a person on a low calorie diet? | 0.112 | 0.035 | 0.044 | 0.073 | **0.641** | 0.319 |
| 67. Imagine you are in a grocery store and there are two kinds of yogurt which their food traffic lights labels are shown below; which product is a healthier choice? | 0.080 | 0.043 | 0.004 | 0.042 | **0.701** | 0.316 |

KaiserMeyerOlkin (KMO) was 0.844. *P* value for Bartlett's Test of Sphericity was <0.001 ($\chi^2$=2932.35, Degree of freedom=351). Bold values are these numbers are factor loadings and for each item the highest value has been highlighted

**Table 5: The results of principal component analysis (Eigenvalues and percentage of explained variance) and reliability testing (Cronbach's Alpha and ICC) for all dimensions of food and nutrition literacy**

| Domains | Dimensions | Number of items | Eigen value | percentage of explained variance | Cronbach's Alpha | ICC/Pearson coefficient |
|---|---|---|---|---|---|---|
| knowledge | Food and nutrition knowledge | 27 | 3.67 | 13.59 | 0.742 | 0.709[a] |
| skills | Functional skills | 11 | 4.185 | 12.68 | 0.823 | 0.903[b] |
| | Interactive skills | 7 | 3.323 | 9.79 | 0.714 | 0.816[b] |
| | Advocacy | 7 | 2.978 | 9.02 | 0.773 | 0.861[b] |
| | Critical analysis of information | 5 | 2.1 | 6.36 | 0.643 | 0.593[b] |
| | Food label reading skills | 3 | 1.919 | 5.81 | 0.559 | 0.681[a] |
| Whole questionnaire | | 60 | | | 0.841 | 0.928 |

ICC, Intraclass Correlation Coefficient. [a]the value is Pearson correlation coefficient. [b]the value is Intraclass Correlation Coefficient

of critical skills, PCA separated them into two constructs which were labeled as "critical analysis of information" and "advocacy". "Advocacy" can be considered as a higher level of critical FNL compared to "critical analysis of information". Accordingly, people who are able to analyze food and nutrition information critically are not necessarily motivated enough to act on advocating for positive changes at community level. This can explain why it is rather logical to place these competencies as two separate constructs.

In the nutrition literacy questionnaire developed by Ndahura *et al*., critical nutrition literacy (CNL) was measured by 3 constructs, including CNL-influence, CNL-media and CNL-action.[22] Items included in "influence" and "media" constructs in their study are similar to what was named "critical analysis of information" in current study; and "action" constructs in Ndahura *et al*. study capture the competencies assessed in "advocacy" domain of FNLAT. It should be noted that in Ndahura *et al*. study, three separate exploratory factor analysis (EFA's) were used to analyze the functional, interactive and critical factors. It's not clear, however, if a single EFA would differentiate items based on these three factors.

After all, Knowledge is not included as a component in some recently developed food literacy questionnaires.[19,20] In the present study, due to the expert's opinion in the qualitative phase, food and nutrition knowledge was included as one of the domains of FNL. The need for inclusion of knowledge as a possible component of food and nutrition literacy has been reported by a recent systematic review,[28] as well as previous studies on Iranian experts.[18] Also, the tool developed through a Delphi study by Liao *et al*. to identify nutrition literacy indicators of Taiwanese college students, has used "understanding" as a proxy of "nutrition knowledge".[21] Therefore, it seems plausible to include knowledge and/or understanding as a component of food and nutrition literacy assessment tools.

In the process of developing FNLAT, as a comprehensive tool with regard to FNL components, available literature and tools were reviewed. None of the tools at the time[22,23] were comprehensive enough to cover all the identified dimensions of FNL. Therefore, while some sections of the available questionnaires[22] were adopted in item pool, many new items were also developed through the process explained above. There were tools that were developed and

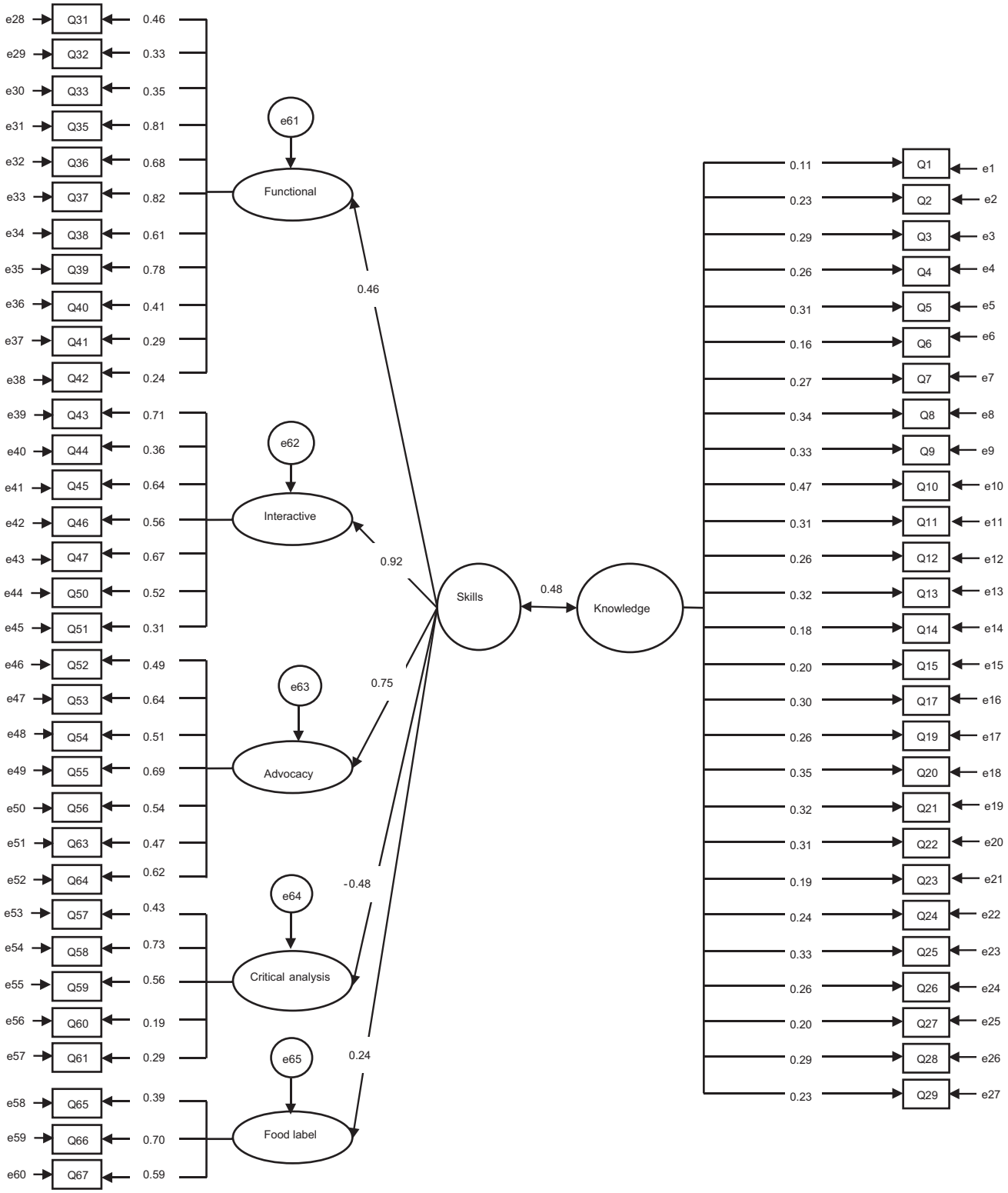


**Figure 3: Confirmatory factor analysis results. Regression weights are standardized and statistically significant ($P < 0.05$) except for knowledge domain items regression weights ($P < 0.15$)**

published while the present study was in data collection stage.[19-21]Further reviewing of these tools also revealed that still none of them is as comprehensive as FNLAT in covering almost all the dimensions of FNL and each has emphasized certain aspects of it (e.g., nutrition knowledge/understanding,[20-23] obtaining food and nutrition

information,[20-22] daily food planning,[19-21] critical analysis of information,[20-22] nutrition and health[20,21]food labels interpreting,[19,23] food choice,[19,21,23] food preparation,[19] healthy budgeting,[19] and social aspects of eating[19]).

CFA confirmed that the suggested model of FNL has acceptable fit. Several model fit indices, including the Chi-squared test to degree of freedom ratio ($\chi^2$/df), RMSEA, RMR and GFI were used in order to assess fitness of suggested model. RMSEA, $\chi^2$/df and RMR value showed acceptable fit of FNL model; however, GFI was close to the minimum acceptable cut-off but did not meet it. Dependency of GFI on sample size and the number of parameters[37,38] may explain this result. Nevertheless, acceptable values of other three fit indices confirm the goodness of model fit and construct validity of the FNLAT.

Examining test-retest reliability and internal consistency of whole questionnaire and most of the dimensions show that the FNLAT meet reliability criteria. However, Cronbach's Alpha values for two dimensions i.e. "critical analysis of information" and "food label reading skills" were lower than acceptable value. This may be due to limited number of items included in the subscale. The lower number of items included in a construct, can affect amount of Cronbach's Alpha.[34] Similar findings have been reported by Doust Mohammadian *et al*., and Ndahura *et al*.[22,26]

One of the strengths of the present study is using a mixed-method approach in the process of development of FNLIT. This approach helped to benefit from the collective wisdom and to avoid subjective decision making. It made it possible to also include the context-specific components of FNL which may differ country by country. Furthermore, applying both PCA and CFA to examine construct validity strengthened the validation process.

It should be noted the despite the comprehensiveness of FNLAT, it cannot completely measure some aspects of skill domain, for example, food preparation skills for which observation may be the preferred method.[39] Therefore, applying a self-rating approach was inevitable in many cases. Although the number of items included in FNLAT has increased the comprehensiveness of the tool; nevertheless, it can also be considered a limitation due to the longer time required to complete the questionnaire. Thus, developing a short form of FNLAT can be an option in situations where there is a time limit.

## Conclusions

The developed instrument makes it possible to depict a more detail and comprehensive picture of FNL status and its determinants in late adolescents and youths. Such information could guide program planners to design more effective interventions. However, considering the fact that many aspects of food and nutrition skills are context-specific and dependent on cultural and social structure, application of FNLAT for the same age group in other countries will require re-evaluation and adjustment before being used.

### Acknowledgments

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### Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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### Conflicts ofinterest

There are no conflicts of interest.

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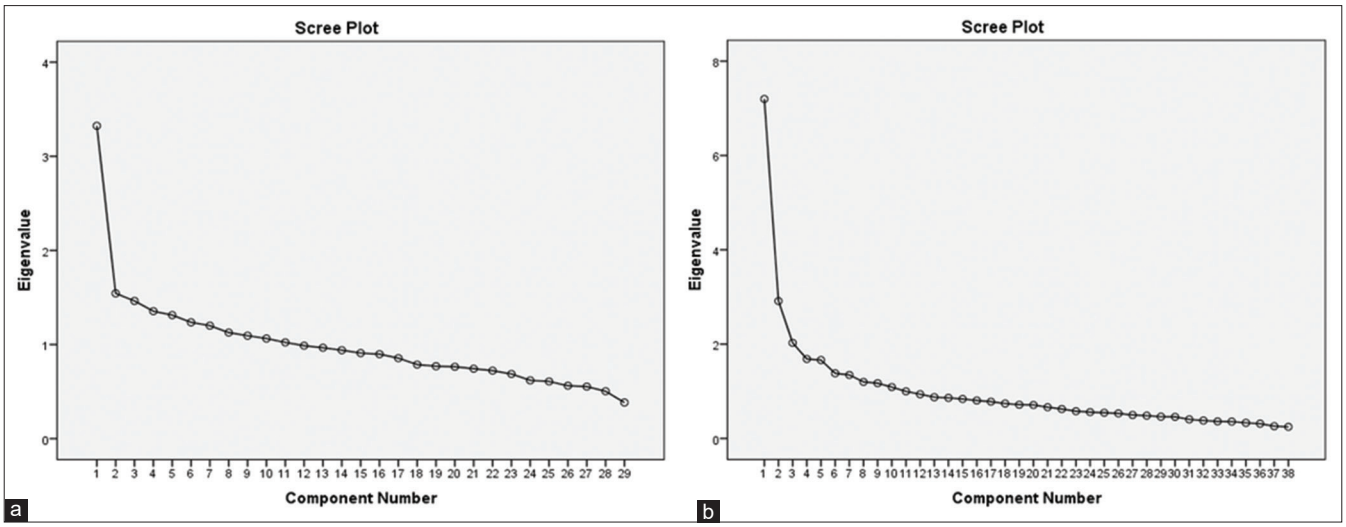


**Appendix I. Scree plot of knowledge (a) and skill (b) domain**

## Appendix II: Factor loadings and α if item deleted for each item in primary model of knowledge domain (before deleting any items)

| Items | Factor loading | Cronbach's α if item deleted |
|---|---|---|
| 1. A balanced meal plan is a plan in which appropriate amounts of each food group is used. | 0.236 | 0.694 |
| 2. Which of the following foods is not included in dairy food group? | 0.284 | 0.691 |
| 3. Which of the following options is equal to one serving of grains food group? | 0.333 | 0.689 |
| 4. Which of following nutrients are mainly provided by meat group? | 0.263 | 0.692 |
| 5. During pregnancy, how does daily requirement of meat (white and red meat) consumption change? | 0.258 | 0.692 |
| 6. Legumes are not the good sources of proteins. | 0.303 | 0.690 |
| 7. Which of following foods are good sources of Calcium? | 0.203 | 0.695 |
| 8. Which of following nutrients do provide energy to our body? | 0.525 | 0.676 |
| 9. Red meat, poultry and eggs are good sources of ……. | 0.295 | 0.691 |
| 10. Trans fatty acids are fatty acids which …… | 0.560 | 0.673 |
| 11.Which of the followings is the best time to add iodized salt to food? | 0.324 | 0.689 |
| 12. Obesity and being overweight during young age is not associated with diabetes in older ages. | 0.425 | 0.682 |
| 13. Osteoporosis occurs as people grow older and cannot be prevented. | 0.319 | 0.692 |
| 14. If you don't have enough money to buy meat, which of following foods will be a more appropriate alternative? | 0.218 | 0.694 |
| 15. Which of following cuts of meat has more fat? | 0.317 | 0.689 |
| 16. In which of the following places you can buy fruits and vegetables with a lower price??[a] | 0.072 | 0.705 |
| 17. Raw meat can be preserved in fridge for one week. | 0.286 | 0.691 |
| 18. Among the cooking methods of meat, barbequing is the healthiest method.[a] | 0.129 | 0.699 |
| 19. In which of the following cooking methods, nutritional values of vegetables are better maintained? | 0.423 | 0.683 |
| 20. Production of 1 kilogram wheat requires more water than production of 1 kilogram of red meat (beef). | 0.270 | 0.691 |
| 21. The difference between pasteurized and sterilized milks is in heating method and the temperature used. | 0.299 | 0.691 |
| 22. Consumption of animal foods harms environment less than plant foods. | 0.394 | 0.685 |
| 23. Using food products which are produced locally can help environmental sustainability. | 0.209 | 0.694 |
| 24. Global warming could affect people's access to adequate and healthy foods. | 0.467 | 0.680 |
| 25. Production of plant foods compared with animal foods results in equal amount of greenhouse gas emission. | 0.403 | 0.684 |
| 26. Imagine you enter a supermarket to choose a healthy snack, which of the following snacks is the healthiest choice? | 0.350 | 0.688 |
| 27. If you are asked to choose the healthiest among the followings to prepare a food, which one will you select? | 0.374 | 0.688 |
| 28.Body mass index (BMI) of a person who weighs 64 Kg and is 170 cm tall equals to: | 0.327 | 0.691 |
| 29. An adult person has a BMI of 27; How do you evaluate his weight status? He she is | 0.450 | 0.684 |

KaiserMeyerOlkin (KMO) was 0.710. *P* value for Bartlett's Test of Sphericity was <0.001 ($\chi^2$=1048.55, Degree of freedom=406). Croanbach's α for primary model of knowledge domain=0.697. [a]These items were deleted in final model of knowledge domain because oflow factor loading and increasing alpha

**Appendix III: Factor loadings and α if item deleted for each item in primary model of skill domain (before deleting any items)**

| Items | Functional skills | Interactive skills | Advocacy | Critical analysis of information | Food label reading skills | Cronbach's α if item deleted |
|---|---|---|---|---|---|---|
| 30. I can manage my weight by exercising and controlling the amount of food I eat.[b] | 0.155 | 0.454 | 0.059 | 0.107 | 0.327 | 0.823 |
| 31. When buying meat, I can recognize its freshness and quality by Checking the appearance. | **0.470** | 0.084 | 0.138 | 0.130 | 0.183 | 0.797 |
| 32. If I have to eat fast Foods (due to lack of time or cooking facilities), I can choose the healthier one. | **0.309** | 0.136 | 0.240 | 0.047 | 0.395 | 0.801 |
| 33. I can buy groceries as much as I need, so that they do not get spoiled or wasted. | **0.231** | 0.125 | 0.093 | 0.089 | 0.500 | 0.803 |
| 34. If my income suddenly is decreased, I will be able manage my expenses so as to buy enough food to ensure my health.[b] | 0.144 | 0.226 | 0.191 | 0.109 | 0.418 | 0.807[a] |
| 35. I am familiar with the basic skills of cooking (e.g. sautéing, frying, stewing rice, using salt and spices, etc.) | **0.815** | 0.021 | 0.041 | 0.007 | 0.015 | 0.786 |
| 36. I know how to preserve foods through using methods such as drying or freezing. | **0.666** | 0.140 | 0.149 | 0.012 | 0.187 | 0.785 |
| 37. I can prepare tasty and healthy foods that me and my family like it. | **0.800** | 0.139 | 0.092 | 0.010 | 0.047 | 0.779 |
| 38. I easily can use cooking equipment such as pressure cooker, stove, and oven. | **0.706** | 0.021 | 0.044 | 0.000 | 0.199 | 0.788 |
| 39. If some ingredients of a recipe are not available, I can change the recipe according to available ingredients. | **0.754** | 0.203 | 0.095 | 0.060 | 0.064 | 0.787 |
| 40. I can make yoghurt from milk. | **0.509** | 0.081 | 0.082 | 0.092 | 0.070 | 0.804 |
| 41. Have you ever experienced planting vegetables (e.g. basil, parsley or tomatoes) in the garden or pots? | **0.475** | 0.129 | 0.008 | 0.067 | 0.082 | 0.802 |
| 42. I can separate dry and wet food disposals. | **0.326** | 0.109 | 0.188 | 0.083 | 0.183 | 0.806 |
| 43. I have collected the nutritional information useful to me from different sources. | 0.214 | **0.644** | 0.139 | 0.071 | 0.118 | 0.306 |
| 44. I use the internet when I am searching information about diet and nutrition. | 0.056 | **0.442** | 0.130 | 0.095 | 0.079 | 0.408 |
| 45. I have changed my food habits based on the information I have got about nutrition. | 0.119 | **0.659** | 0.113 | 0.139 | 0.203 | 0.326 |
| 46. I usually follow TV or radio talk shows on nutrition. | 0.127 | **0.490** | 0.150 | 0.217 | 0.091 | 0.397 |
| 47. I follow information on characteristics of a balanced diet. | 0.147 | **0.655** | 0.122 | 0.239 | 0.106 | 0.348 |
| 48. I can ask dietary experts (e.g., doctors, nurses, etc.) questions about healthy eating.[b] | -0.174 | **-0.560** | 0.122 | 0.059 | 0.001 | 0.646 |
| 49. When I am looking for information about nutrition, I don't know which section in the health centers I can go to for help.[b] | 0.083 | -0.242 | 0.058 | 0.004 | **0.391** | 0.546 |
| 50. I discuss my thoughts about diet with others (including family, friends, and doctors). | 0.143 | **0.563** | 0.197 | 0.027 | -0.036 | 0.386 |
| 51. If I go to grocery stores independently, I can easily ask the seller for the information I need. | 0.106 | **0.317** | 0.274 | 0.028 | 0.188 | 0.429 |
| 52. I can easily get involved in political discussion aiming at improving nutritional status of Iranian people. | 0.213 | 0.304 | **0.388** | 0.072 | 0.182 | 0.765 |
| 53. I am interested in taking an active role in activities aiming at promoting healthy diet. | 0.178 | **0.461** | **0.423** | 0.261 | 0.045 | 0.743 |
| 54. I expect my school or work place to serve healthy foods. | 0.057 | 0.039 | **0.717** | 0.015 | 0.249 | 0.751 |

*Contd...*

**Appendix III: Contd...**

| Items | Functional skills | Interactive skills | Advocacy | Critical analysis of information | Food label reading skills | Cronbach's α if item deleted |
|---|---|---|---|---|---|---|
| 55. I try to convince others (e.g., my family or friends) to eat healthy foods. | 0.066 | 0.376 | **0.601** | 0.057 | 0.113 | 0.738 |
| 56. It's important for me various healthy foods to be available to choose in the school canteens. | 0.024 | 0.038 | **0.780** | 0.092 | 0.162 | 0.737 |
| 63 I am an environmentalist and willing to voluntarily work toward supporting Eco-friendly methods of food production. | 0.188 | 0.150 | **0.525** | 0.123 | 0.096 | 0.751 |
| 64. I am interested in voluntary activities to reduce unhealthy snacks and fast food availability in my neighborhood, school or workplace. | 0.220 | 0.184 | **0.632** | 0.119 | 0.193 | 0.727 |
| 57. I am usually influenced by nutritional recommendation made by my family and friends. | 0.024 | 0.187 | 0.312 | **0.448** | 0.125 | 0.488 |
| 58. I trust different diets that I read about in newspapers and magazines. | 0.008 | 0.166 | 0.105 | **0.753** | 0.015 | 0.410 |
| 59. I believe that the scientific findings on nutrition, food and diet discussed in mass media are correct. | 0.058 | 0.205 | 0.068 | **0.676** | -0.117 | 0.444 |
| 60. It's difficult for me to distinguish between scientific and non-scientific materials about diet. | 0.143 | 0.068 | 0.018 | **0.434** | 0.098 | 0.495 |
| 61. The claims advertised by food manufacturers about the positive health effects of their food products are reliable. | 0.077 | 0.030 | 0.041 | **0.617** | 0.020 | 0.468 |
| 62. I don't easily accept food and nutrition information I receive from virtual networks, and research about their truthfulness.[b] | 0.062 | **0.406** | 0.301 | 0.241 | 0.237 | 0.644 |
| 65. If you eat a package of cheese with the following label information, how much calories you will get from this product? | 0.003 | 0.148 | 0.048 | 0.124 | **0.445** | 0.614 |
| 66. Considering food labels of product 1 and product 2, which one is more appropriate for a person on a low calorie diet? | 0.109 | 0.028 | 0.042 | 0.143 | **0.516** | 0.319 |
| 67. Imagine you are in a grocery store and there are two kinds of yogurt which their food traffic lights labels are shown below; which product is a healthier choice? | 0.079 | 0.054 | 0.015 | 0.094 | **0.580** | 0.316 |

KaiserMeyerOlkin (KMO) was 0.844. *P* value for Bartlett's Test of Sphericity was <0.001 ($\chi^2$=3325.51, Degree of freedom=703). In primary model of skill domain, Cronbach's Alpha for functional skills, interactive skills, advocacy, critical analysis of information and food label reading skills were 0.811, 0.468, 0.773, 0.543, and 0.550 respectively. [a]After removing item 30, α if item deleted for item 34=0.823. [b]These items were deleted in the final model of skill domain