Revisión

Systematic review of healthy eating indexes in adults and elderly: applicability and validity

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Abstract

Introduction: **The Healthy Eating Index (HEI) assesses a combination of different types of foods, nutrients and dietary components. It has been adapted in some countries, considering the local dietary habits.**

Objective: **in this article, the Healthy Eating Indexes published to date were identified by means of a systematic review. Besides, issues relating to their validity, applicability and limitations were discussed.**

Methods: **an electronic search was performed in the PUBMED, SCIENCE DIRECT, BVS and SciELO data base containing studies on the adaptation, review, update or validation of the HEI. The descriptors Healthy Eating Index, Index of Diet Quality, Quality of diet, Diet surveys were used, in different combinations.**

Results: **a total of 11 studies were described and critically analyzed. One of the studies dealt with the development of the index; six proposed adjustments; two assessed validity and reliability of the index, and the other two proposed revision and update. The Healthy Eating Indexes reveal the actual quality of the diet, but the absence of a methodological standard hinders the comparison of the results found in different populations.**

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Key words: *Quality of diet. Diet surveys. Diet. Healthy Eating Index.*

REVISIÓN SISTEMÁTICA DE LOS ÍNDICES DE ALIMENTACIÓN SALUDABLE DE ADULTOS Y ANCIANOS: APLICABILIDAD Y VALIDEZ

Resumen

Introducción: **los índices de alimentación saludable evalúan la combinación de diferentes tipos de alimentos, nutrientes y componentes de la dieta. Estos indicadores han sido adaptados en algunos países considerando las directrices dietéticas locales.**

Objetivo: **esta revisión sistemática identifica todos los índices de alimentación saludable publicados hasta el momento; así mismo, discute la validez, aplicabilidad y limitaciones de los mismos.**

Métodos: **para ello se realizó una búsqueda electrónica en PubMed, Science Direct, BVS y SciELO utilizando los siguientes términos:** *Healthy Eating Index*, *Index of Diet Quality*, *Quality of diet* y *Diet surveys* **con diferentes combinaciones e idiomas.**

Resultados: **un total de 11 estudios fueron seleccionados y analizados críticamente: entre ellos, un estudio que desarrolla el primer índice, seis estudios en los que se proponen ajustes en la metodología utilizada, dos estudios que evaluan la validez y la fiabilidade, así como dos de revisión y actualización. Los datos muestran que los índices de alimentación saludable son buenas herramientas para valorar la calidad de la dieta, pero la falta de estandarización en la metodología hace difícil la comparación entre los resultados de las diferentes poblaciones.**

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Palabras clave: *Calidad de la dieta. Encuestas de dieta. Dieta. Índice de alimentación saludable.*

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Introduction

Dietary factors are associated with both the genesis and prevention of chronic non-communicable diseases. According to estimates, changes in food habits can reduce by 30% the incidence of cardiovascular diseases, which are the main cause of mortality worldwide[1,2].Therefore, interest in the assessment of the relationship be-

tween diet and disease has increased the publication of epidemiological and intervention studies[3–6].

Dietary indexes have been developed to assess food intake based on population dietary guidelines, considering the number of portions consumed, food variety in the diet and the adequacy of nutrient intake. These indexes help monitoring the diet of individuals and populations, in relation to nutritional recommendations. However, their application depends on adaptations that consider the eating habits of each country[1,7–10].

The Healthy Eating Index developed by Kennedy et al. (1995)[7], (HEI-1995) was based on dietary recommendations for the US population (*Dietary Guidelines for Americans*, 1990) and is considered an appropriate tool for measuring general food quality[1,11]. HEI was initially composed of ten components (five food groups, total and saturated fat, cholesterol, sodium and dietary variety), based on different aspects of healthy eating conditions. The score ranged from 0 to 10 for each component, totaling 100 points distributed in numerical ranges that can be categorized into "healthy" (score ≥80), "needs modification" (scores between 51 and 80) and "inappropriate" (score ≤ 51)[7,12–14]. This index has been adapted in some countries according to the local nutritional recommendations and orientation. This work aimed to identify the adjustments and reviews carried out from the original Healthy Eating Index and discuss their validity, applicability and limitations in population studies.

Methods

Literature search

The searches were conducted in the data bases Publicações Médicas (PUBMED), Science, health and medical journals (SCIENCE DIRECT), Biblioteca Virtual em Saúde (BVS) and Scientific Electronic Library Online (SciELO), using the keywords *Healthy Eating Index*, *Index of Diet Quality*, *Quality of diet* and *Diet surveys* in different combinations. English terms were used for all databases.

Selection criteria

The articles selected addressed the methodology of HEI adaptation, review, update or validation in adult or elderly population. Articles that used HEI as a tool to evaluate the food consumption of a given population were excluded, as well as those related to a diet quality index or other types of indexes and review articles.

After the databases weresearched, the articles were selected according to their titles. Then, the studies in the data bases presenting duplicity were excluded. Next, the abstracts of the eligible studies were read and when reading the abstract was not enough to check if the inclusion criteria were met, the articles were read in full. When the abstract was sufficient, the articles were selected and

then the full version was obtained for reading and confirmation of eligibility and inclusion in the study.

The articles found in the initial search were first assessed according to their title. Then, the analyses of duplicity, reading of the abstract and of the full text were conducted. Those selected for analysis were described according to the authors, year of publication, location, HEI used, number of participants, purpose, age group, HEI characteristics, dietary survey used and main results.

Results

The literature search in electronic databases provided 1364 articles whose titles were analyzed. After the exclusion factors were applied, 38 articles remained for eligibility assessment. After analysis of duplicity and reading of the abstracts, 15 articles were selected for reading in full, and 4 of them were excluded for relating to the diet quality index and not the HEI (Figure 1). Thus, eleven studies were analyzed in this research work[1,5,7–11,15–18].

Most studies have been published in the United States and Brazil, between 1995 and 2013 (Figure 2), and have proposed adjustments to HEI application in other populations (Table I), based on the study that gave rise to the HEI.

The indexes allow rating the quality of the diet, thus indicating a need for improvements based on scoring categories, so that the higher the score the better the quality of the diet. Considering the characteristics of the index, we observe variation in the number of components (10 to 12), food groups included, dietary recommendations; nutrients and diet variety. The 24-hour diet recall was the diet survey most widely used for obtaining diet information[1,5,7–10,15–17].

In Brazil, the first two HEI adaptation proposals emerged from the inclusion of components of the Adapted Food Pyramid for Brazilian population[1,5]. However, the Revised HEI was proposed (HEI-R), due to the publication of the Guia Alimentar Para a População Brasileira (Food Guide for the Brazilian Population) in 2006. It contains 12 components based on energy density (portion/1000 kcal) or percentage of calorie participation in the diet[9]. This Revised Index was reliable and valid to assess diet quality[10].

In Brazil, the term ''Healthy Eating Index'' was mistranslated into Índice de Qualidade da Dieta (IQD) (Index of Diet Quality), since there is another index with the same title. Thus, the term "Index of Diet Quality" was included in the search, and it was verified if it referred to the HEI.

Discussion

Before the development of the HEI, the indexes were limited to the analysis of the nutrients consumed, such as total fat, saturated fat, cholesterol and sodium, by
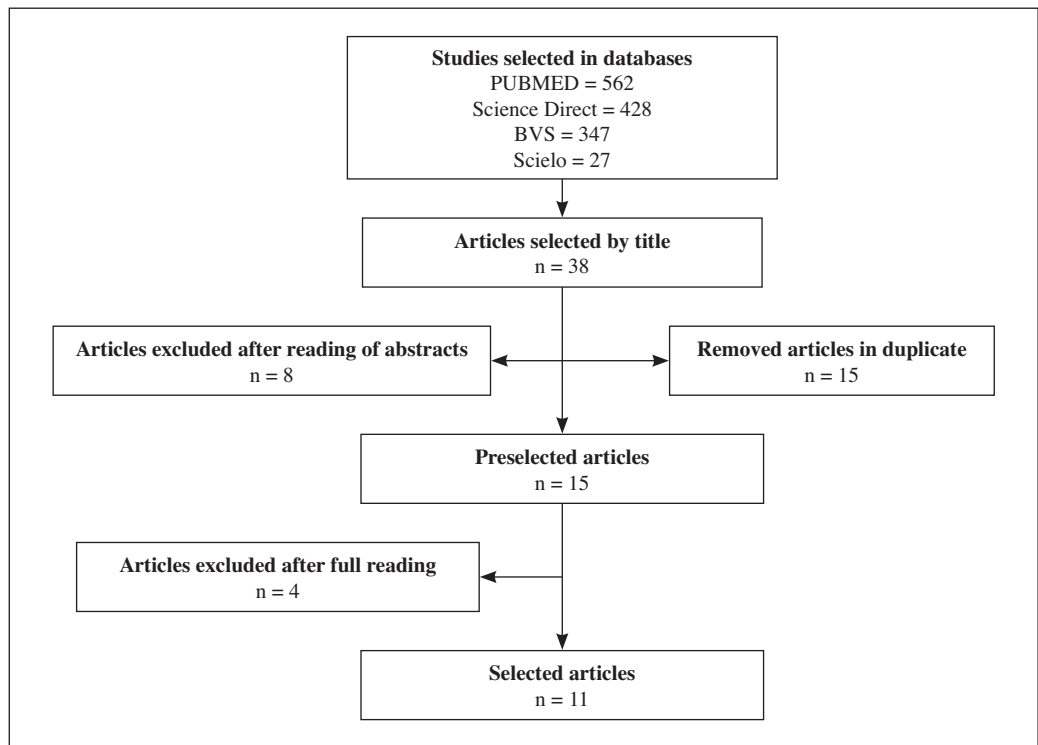
Fig. 1.—Literature search and selection.

means of the average adequacy or percentage, considering the dietary recommendations. In 1990, studies on diet quality with the food groups proposed in the Dietary Guidelines for Americans (1990) started to be published and Patterson et al. (1994)[19] were the first to establish that relationship[7].

The Center for the Promotion of Nutrition Policy of the US Department of Agriculture released HEI in 1995, based on dietary guidelines and scientific information, thus providing a more comprehensive set of diet quality indicators compared to previous studies. Its development considered dietary components that could be
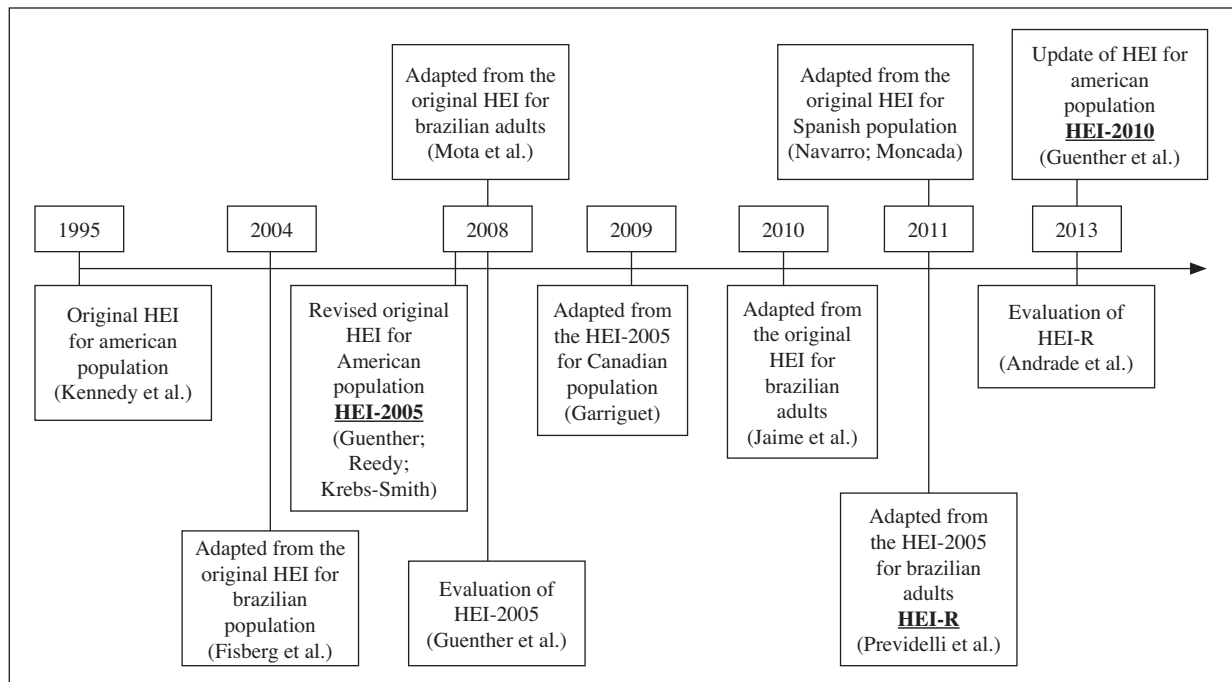

Fig. 2.—Timeline of the publication period.

Table I

Characteristics of the studies on validation, adaptation and review of the Healthy Eating Index (HEI)

Author (year) Location	Type of HEI proposed	Number of participants and age group	Methodological Proposal	Characteristics of HEI/ Diet Survey Method	Main results/ Conclusions
Kennedy et al. (1995)[7] United States	Original HEI (HEI-1995)	n = 7463 Children (> 2 years); Adolescents; Adults; Elderly	Development of a global diet quality index based on the 1992 American Food Pyramid.	Total of components: 10 1-5: cereals, vegetables, fruits, meat and milk-7-10: percentage of total fat and saturated fat, cholesterol intake, sodium intake, dietary variety. Diet survey reference: 24-hour recall and Diet record (2 days)	Average HEI score: 63.9. Most people reported low intake of fruits and vegetables. HEI presented positive and significant correlation with most nutrients. HEI is useful to monitor changes in food intake over time.
Fisberg et al. (2004)[1] Brazil	HEI adapted for the Brazilian population from the HEI-1995.	n = 50 Children (> 1 year); Adolescents; Adults; Elderly	Adaptation of HEI-1995 for the Brazilian population based on the 1999 Brazilian Food Pyramid.	Total of components: 10 - 1 to 6: cereals, breads and tubers, vegetables, fruits, meat and eggs, dairy products and legumes - 7-10: Percentage of total fat, cholesterol intake, sodium and dietary variety. Diet survey reference: 24-hour recall	Average HEI score: 51.1. - 12%: Healthy diet - 74%: A diet that needs changes - 14%: Poor diet The application of HEI in the study population is feasible.
Guenther; Reedy; Krebs-Smith (2008)[8] United States	HEI revised for the American population (HEI-2005)	n = 8650 Children (> 2 years); Adolescents; Adults; Elderly	HEI-1995 based on the 2005 American Food Pyramid (*My Pyramid*)	Total of components: 12 1 to 9: total fruits, whole fruits, total vegetables, dark green and orange vegetables, legumes, milk and dairy products, total cereals, whole cereals, meat and legumes, oils. 10 and 11: saturated fat and sodium 12: calories from solid fat, alcohol and sugar addition (Gord_AA). Included adjustment of food intake to 1,000 calories. Diet survey reference: 24-hour recall	Addresses the consumption of highly energetic foods with low nutritional value; Considers aspects of the American diet which do not comply with the current recommendations. HEI-2005 assesses diet quality, according to the 2005 Dietary Guidelines.
Mota et al. (2008)[5] Brazil	HEI adapted for the Brazilian population from HEI-1995	n = 502 Adults	Adaptation of HEI-1995 for the Brazilian population based on the Food Guide for the Brazilian Population (2006) and the Adapted Food Pyramid (1999)	Total of Components: 12 -1 to 8: Group composed of cereals, breads, tubers and roots; vegetables; fruit; legumes; meat; dairy products; oils and fats; sugars and sweets. - 9 to 12: percentages of total and saturated fat, cholesterol intake and diet variety Diet survey reference: 24-hour recall	Average HEI score: 86.7. - 15% à presented good quality diet - 71% à diet needs improvement - 14% à poor diet The adapted HEI can be used to assess population eating habits but it is specific for the adult Brazilian population.
Garriguet (2009)[16] Canada	HEI adapted from HEI-2005 for the Canadian population	n = 33.664 Children (> 2 years); Adolescents; Adults; Elderly	Adaptation of HEI-2005 for the Canadian population based on the Canadian Food Guide (2007).	Total of components: 11 - 1 to 8: Total vegetables and fruits, whole fruits, dark green and orange vegetables, total of cereals, whole grains, milk and dairy products, meat and meat products, and unsaturated fats - 9 to 12: percentage of saturated fat and intake of sodium and "other foods" (empty calories). Diet survey reference: 24-hour recall	Average HEI score: 58.8. The American HEI can be adapted, according to the Canadian dietary recommendations.

Table I (cont.)

Characteristics of the studies on validation, adaptation and review of the Healthy Eating Index (HEI)

Author (year) Location	Type of HEI proposed	Number of participants and age group	Methodological Proposal	Characteristics of HEI/ Diet Survey Method	Main results/ Conclusions
Jaime et al. (2010)[17] Brazil	Energy-adjusted HEI (HEI-a)	n = 737 Adults	Development of an energy-adjusted HEI based on the HEI adapted for the Brazilian population by Fisberg et al. (2004).	Tests used: - Pearson correlation. - Adjust the total dietary energy using waste method. - Reliability (internal consistency) according to Cronbach's alpha. Diet survey reference: 24-hour recall	Cereals and tubers are the food group with greater variation in total portions. The Cronbach's alpha of HEI-a was 0.643 and the index correlated with most nutrients. HEI can be considered an important tool for the assessment of the quality of Brazilian population diet.
Navarro; Moncada (2011)[18] Spain	HEI adapted for the Spanish population (IASE)	n = 29478 Adolescents (>16 years); Adults; Elderly	Adaptation of the HEI-1995 for the Spanish population based on the Spanish Healthy Food Guide (2004).	Total of components: 10 - 1-4: Daily consumption: cereal and cereal products, vegetables, fruits, milk and dairy products; - 5 and 6: Weekly consumption: meat, legumes; -7 To 9: occasional consumption: sausages and refrigerated food, sweets, sweetened beverages - 10: Diet variety. - Score criteria based on the frequency of consumption. Diet survey reference: Food frequency questionnaire	Average HEI score: 69.95 (men); 73.73 (women). 72 % à need changes in their eating standards. IASE is a quick and inexpensive method to estimate diet quality in the population.
Andrade et al. (2013)[10] Brazil	HEI-R Relative Validation	n = 2.375 Adolescents (≥ 12 years); Adults; Elderly	Assessment of the validity and reliability of the HEI adapted by Previdelli et al. (2011 based on the Food Guide for the Brazilian Population (2006).	Aspects assessed: - Content validity; - Construct validity, through principal components factor analysis - Discriminant validity; - Reliability (internal consistency) according to Cronbach's alpha Diet survey reference: 24-hour recall	The Cronbach's alpha value (α = 0.7) indicated the presence of internal consistency among the components of HEI-R. The Gord_AA component, followed by the components total fruits and wholesome fruits, showed higher correlation with the final index score. It was observed that the components of the HEI-R include six of the seven guidelines of the Food Guide for the Brazilian population. It proved reliable and structurally valid when used to evaluate and monitor the quality of the Brazilian diet.

Table I (cont.)

Characteristics of the studies on validation, adaptation and review of the Healthy Eating Index (HEI)

Author (year) Location	Type of HEI proposed	Number of participants and age group	Methodological Proposal	Characteristics of HEI/ Diet Survey Method	Main results/ Conclusions
Guenther et al. (2013)[11] United States	HEI revised for the American population (HEI-2010)	-	Revision of HEI-2005 based on the Dietary Guidelines for Americans 2010.	Total of components: 12. Changes: - Green vegetables, beans replacing dark green vegetables, orange vegetables and legumes; - Addition of seafood and plant proteins to detect specific choices of protein group; - Fatty acids replacing oils and saturated fat; - Refined cereals replacing total cereals, to assess excessive consumption. Diet survey reference: -	HEI-2010 captures the major recommendations of the Dietary Guidelines for Americans 2010. Used to assess the quality of the diet of the population, interventions, dietary patterns and various aspects of food environment.

related to obesity and overweight, which was already a public health problem in the United States at that time. The application of HEI in the data of the Continuing Survey of Food Intakes by Individuals (CSFII), from 1994 to 1996, showed that most of the American population showed low intake of fruits, milk and dairy products and a HEI average score of 63.6[12], which is close to that found by Kennedy et al. (1995)[7], 63.5. Then, the use of HEI was proposed to monitor changes in dietary intake over time[7,8] and indicate the need for improved food quality.

Studies based on the HEI adapted by Kennedy et al. (1995)[7] have found that the diet of the majority of Brazilian and Spanish populations needed modification[1,5,18]. In the study conducted by Kennedy et al. (1995)[7], the average score of 2 to 3% of the sample was less than 40, and of 11 to 12%, above 80. Garriguet (2009)[16] found that almost 17% of his sample obtained scores lower than 50, while less than 1% were higher than 80. However, variation was observed in the score ranges proposed to rate diets according to the scores given by HEI, which limits the comparison between study results.

HEI is revised based on updates of dietary guidelines and food guides in each country. In the United States, for example, HEI-1995 was revised based on the recommendations of the My Pyramid (2005), giving rise to the HEI-2005 which now includes whole fruit; dark green and orange vegetables and legumes; whole grains and calories from solid fat, alcohol and added sugar (Gord_AA). In addition, it introduced adjustment by caloric density (1000 calories) to characterize diet quality by controlling its amount. In HEI-2005, diet variety was not computed in a specific item, due to the stratification of food items into whole fruits, dark green vegetables and whole grains[8,20].

The healthy eating indexes proposed after HEI-2005 stratifies the dietary components into adequacy and moderation. The adequacy components refer to the consumption of more servings of certain food groups (total fruits; whole fruits, total vegetables, green and orange vegetables and legumes, total cereals, whole grains, milk, meat and beans and oils), while moderation relates to lower consumption of saturated fat; sodium; calories from solid fats; alcoholic beverages and added sugar. The score of the components of adjustment was based on a minimum score (zero) for no ingestion; and, as consumption increases, the scores increase proportionally[8].

The consumption of the recommended amounts of vegetables, fruits and whole grains increases scores and helps reducing the risk of developing obesity, cardiovascular disease, dyslipidemia, diabetes mellitus, hypertension, osteoporosis and cancer[21–25]. Saturated fat, sodium and calories from solid fats, alcoholic beverages and added sugars should be consumed moderately and the score is inversely proportional to the amount consumed[8], due to the relationship between the excessive consumption of these components and increased risk of chronic diseases, certain types of cancers and metabolic disorders[25,26].

In the case of the Dietary Guidelines for Americans 2010, it was necessary to update HEI-2005, which resulted in HEI-2010. The component ''Dark green and orange vegetables and legumes" was replaced by the component ''Greens and Beans", since their intake was close to the recommended levels; the component 'fatty acids' was replaced by 'Oils' 'and' 'Saturated Fat', considering that the type of fat is more important than the total amount of fat. The component "refined grains" was replaced by ''Total Grains", due to their high consumption level. The term empty calories replaced Gord_AA, while the component ''Seafood and plant proteins" was included, considering the vegetarian diets and reduced cardiovascular risk[11].

The adaptations of HEI take into consideration the dietary recommendations of each nationality aiming to apply the index to measure the dietary risk factors for non-communicable chronic diseases and simultaneously assess population food habits[1,5,9,15,16,18,20].

Studies on HEI relative validity and reliability[10,15,17] concluded that this index is valid for measuring diet quality, but variations in the scoring procedures hinder comparisons. In recent years, the proposals of validity and reliability have been based on four criteria[15]: (I) content validity: based on the comparison of the components of the HEI proposed with the guidelines and food guides (ii) construct validity: investigates whether HEI assesses diet quality regardless of the energy amount ingested by means of the Pearson correlation analysis and principal components factor analysis (ACP); (iii) discriminant validity: assesses the index ability to differentiate diet quality in various population groups, and (iv) reliability: assessment based on Cronbach's alpha (α)[10].

The score is provided by the quantitative analysis of food consumption. The interviewer should be well trained to ensure better data accuracy. Moreover, the Brazilian food composition tables are still limited for this type of assessment, mainly for types of fats and alcoholic beverages. Whereas this method aims to analyze the diet quality of population groups, its use in clinical practice is limited by delay and lack of computer programs that perform this type of evaluation.

We observed that HEI is a useful method to estimate diet quality. It is valid and reliable, and can be thus adapted. However, the analysis of the development of HEI methodologies shows that there is no standardization. Some studies refer to the HEI developed in 1995 and others, to HEI-2005. Besides, there is no standardization for the number of items and score range, which hinders comparison. Research is needed to revise the instrument, according to the new nutritional recommendations, and standardize it.

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