ORIGINAL ARTICLE / *ARTIGO ORIGINAL*

Convergent validity and invariance analysis of a scale to measure adherence to eating practices recommended by the Dietary Guidelines for the Brazilian Population

Validade convergente e análise de invariância de uma escala de adesão a práticas alimentares recomendadas pelo Guia Alimentar para a População Brasileira

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ABSTRACT: *Objective:* To analyze the convergent validity and invariance of a scale to measure adherence to eating practices recommended by the Dietary Guidelines for the Brazilian Population. *Methods:* A subsample (n=1309) of the NutriNet-Brasil cohort (self-filled web-based study) answered the 24-items scale based on the Guide, as well as socioeconomic and dietary questionnaires. The score in the scale (*eGuia*) was compared by Spearman's correlation with scores of fresh and minimally processed foods (*eG1*) and ultra-processed foods (*eG4*) consumption, both composed of the average number of food items consumed in three random days. Correlations' direction and strength were observed to infer convergent validity. A multi-group confirmatory factor analysis was used to assess scale invariance at the configural, factorial and metric levels, between subgroups of sex (men/women), age (≤37/>37, being 37 the median) and years of schooling (≤11/>11). The model was invariant when the goodness-of-fit indices varied within acceptable ranges compared to the previous level. *Results:* Participants were on average 39 years old (sd=13.7), 53% were women and 69% had more than 11 years of education. Correlations between *eGuia* and *eG1,* and between *eGuia* and *eG4* were 0.56 and -0.51 (p<0.001), respectively. In all sociodemographic groups, the goodness-of-fit indices varied within acceptable ranges. *Conclusion:* The correlations show that the eating practices measured by the scale are aligned with a healthy food consumption, showing its convergent validity. In this sample, the scale measured the same dimensions, showed equivalence of items' factor loadings, and generated comparable scores between subgroups of sex, age, and education.

Keywords: Food guide. Food behaviour. Psychometrics. Validation study.

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RESUMO: *Objetivo:* Avaliar a validade convergente e a invariância de uma escala de adesão a práticas alimentares recomendadas pelo *Guia Alimentar para a População Brasileira*. *Métodos:* Uma subamostra (n=1.309) da coorte NutriNet-Brasil (estudo *online* autopreenchido) respondeu à escala baseada no guia (24 itens) e a questionários socioeconômicos e alimentares. O escore na escala (*eGuia*) foi comparado por meio de correlação de Spearman a escores de consumo de alimentos *in natura* e minimamente processados (*eG1*) e ultraprocessados (*eG4*), compostos do número médio de alimentos desses grupos consumidos em três dias aleatórios. Para inferência de validade convergente, observaram-se o sentido e a magnitude das correlações. Empregou-se análise fatorial confirmatória com múltiplos grupos para avaliar a invariância nos níveis configural, fatorial e escalar, entre subgrupos de sexo (homens/mulheres), idade (≤37/>37, sendo 37 a mediana) e anos de estudo (≤11/>11). Considerou-se o modelo invariante quando os índices de ajuste variaram nos limites aceitáveis ante o nível anterior. *Resultados:* Os participantes tinham em média 39 anos (desvio padrão — DP=13,7), 53% eram mulheres e 69% tinham mais de 11 anos de estudo. As correlações entre *eGuia* e *eG1* e *eGuia* e *eG4* foram 0,56 e -0,51 (p<0,001), respectivamente. Em todos os subgrupos, os índices de ajuste variaram nos limites aceitáveis. *Conclusão:* As correlações mostram que as práticas alimentares medidas pela escala estão associadas ao consumo alimentar saudável, demonstrando validade convergente. Nessa amostra, a escala mediu as mesmas dimensões, apresentou equivalência nas cargas fatoriais dos itens e gerou escores comparáveis entre diferentes subgrupos de sexo, idade e escolaridade.

Palavras-chave: Guias alimentares. Hábitos alimentares. Psicometria. Estudo de validação.

INTRODUCTION

The Dietary Guidelines for the Brazilian Population is based on an expanded concept of healthy eating that takes into account biological, sociocultural and environmental aspects linked to the health and well-being of individuals and communities. Its recommendations cover practices surrounding the whole eating process—from the food choice to the settings in which it is consumed—and takes into account possible obstacles posed by contemporary lifestyles. In a non-quantitative format, the recommendations are expressed with terms such as "avoid" or "limit" and presented as an easy-to-understand text with illustrations[1-4].

If, on the one hand, qualitative recommendations facilitate the dissemination and implementation of food guidelines because they are simpler, realistic and flexible[2,5], on the other hand, they are a challenge when it comes to the measurement of population adherence. Therefore, a self-administered scale to assess adherence to recommendations was developed and underwent initial validation steps. The scale contained 24 items that portray dietary practices recommended or discouraged by the document, and respondents were supposed to indicate how often they adhere to such practices in their daily lives[6].

This instrument has been widely used not only for data collection in scientific research but also as a means of health promotion in health services. Three studies were identified in the literature using the scale, two of which described lifestyles and health-related behaviors of population groups in Brazil[7,8,] while the other described sociodemographic factors associated with the score on the scale[9]. In addition, the scale composes the test "How is your diet?",

from the Ministry of Health, printed as a flier[10] and published in the ConectSUS[11] application, being recommended in obesity management activities in the context of Primary Health Care[12].

Despite these applications, additional validation steps are essential so that the use of this scale is more widespread and encouraged. In a previous study, it underwent content validation (by a panel of experts), draft validation (pre-tests with target audience) and initial stages of construct validation (internal structure analysis via exploratory and confirmatory factor analyses)[6]. However, according to the concept of validation by Furr and Bacharach[13], one must still verify whether the measure generated by the scale correlates with variables that are theoretically associated with each other and whether it allows comparisons between different subgroups of the population.

Of the two missing aspects, the first can be evaluated through convergent validation and is important to confirm the construct. The second can be tested by means of invariance analysis and is essential for analyzing the distribution of the phenomenon in the population, as it allows comparison between groups[13]. This study aims to verify the convergent validity and invariance of a scale that measures adherence to the recommendations of the Dietary Guide for the Brazilian Population.

METHODS

PARTICIPANTS AND DATA COLLECTION

Study carried out with a subsample of participants from the NutriNet-Brasil cohort, a fully online survey coordinated by the Center for Epidemiological Research in Nutrition and Health at USP (NUPENS-USP), whose objective was to investigate the relation between diet and morbidity/mortality from chronic non-communicable diseases in Brazil. People aged 18 and over living in Brazil voluntarily participated. The selection of participants in this research took place in two stages:

1. Drawing of a subsample of cohort participants to respond to the scale; and
2. Application of the inclusion criteria of the present investigation.

In the first stage, the objective of the draw was to obtain complete answers from 1,225 individuals (sample calculation performed according to the needs of another study linked to the same research project) distributed in quotas according to sex, educational level and region of residence, following proportions observed in the demographic census of 2010 from the Brazilian Institute of Geography and Statistics (IBGE). Regarding education, it was taken into account that, in NutriNet-Brasil, a greater participation of individuals with a higher level of education is expected than that observed in the Brazilian population in general. Therefore, two education groups were established with a cut-off point at the highest level collected by the IBGE, "up to complete high school" and "complete higher education or more". Participants from NutriNet-Brasil who had reached the tenth month of follow-up

were eligible for this draw, as the present study required data collected in questionnaires applied in previous months of follow-up (n=48,091).

In order for all quotas to be filled, a total of individuals equivalent to three times the desired number were notified in each quota, with the exception of quotas whose goal was lower than 30, for which 90 individuals were notified. Thus, 4,206 individuals were contacted, of which 2,083 responded to the scale, fulfilling all quotas. In the second stage, participants eligible for this research were selected based on the inclusion criterion established—having answered three food questionnaires within a maximum range of 60 days—, totaling 1,309 subjects. Important to stress out that this number exceeds the recommended minimum of 200 individuals for convergent validation, which is required even for weak correlations to be statistically significant[14].

INSTRUMENTS

Scale of dietary practices according to recommendations of the Dietary Guide for the Brazilian Population

This is a self-administered scale aimed at the adult Brazilian population (18 to 60 years old), with 24 four-point Likert-type items ("never", "rarely", "often", "always"), comprising four dimensions of adequate and healthy eating addressed in the guide: food choice, modes of eating, planning and household organization.

Its development was based on elaboration of a pool of 96 items, afterwards submitted to a panel of experts, to pre-tests with potential users of the scale and to dimensionality tests. The final version, tested for application both in printed version and electronically, also underwent a reproducibility study[6]. Prior to data collection for this research, a group of experts carried out a new round of review, which resulted in wording adjustments for six items. In addition, the response options of the original version ("strongly disagree", "disagree", "agree" and "strongly agree") were replaced by the current frequency scale, as proposed by experts. The new proposal was previously tested with 300 subjects, and the instrument was found to retain its psychometric properties (unpublished data).

Table 1 of the Supplementary Material shows the items according to dimension, from most to least representative of each one, that is, items that had higher factorial loads in the confirmatory factor analysis performed in the previous study[6]. Items that were somewhat changed are accompanied by their original version.

Food consumption questionnaire according to NOVA

In order to obtain the variables for comparison, a questionnaire was used to estimate the consumption of fresh and minimally processed foods (G1) and ultra-processed foods

(G4), extreme groups of the NOVA classification[15,16]. In this questionnaire, the individual is asked to select all items consumed on the previous day from a list of 33 G1 foods and 24 G4 foods. G1 items are distributed as fruits (10), greenery (9), vegetables (9) and whole grains (5); G4 items comprise sweetened beverages (6), products that replace or accompany meals (10), and products commonly consumed in the form of snacks (7) (full version available in Table 2 of the Supplementary Material). An original version of this questionnaire was validated with users at a Primary Health Care service[15]. The part related to G4 in the version adapted for NutriNet-Brasil, used in this investigation, has already been validated[16]; the validation of G1 components will be published soon. Each individual answered the questionnaire on three non-consecutive random days, with intervals of 15 to 30 days, to minimize intra-individual variability of food consumption[17].

Statistical analysis

Convergent Validation

The score on the total scale (eGuide) and by dimension was calculated by the simple sum of answers provided to each item, with "never" = 0, "rarely" = 1, "often" = 2 and "always" = 3 for the direct items (planning and household organization dimensions), or the opposite for inverted items, in which the answer "never" represents the most appropriate practice and, therefore, receives the score of 3 (modes of eating and food choice dimensions). Thus, the score can range from 0 to 72. Consumption scores of fresh and minimally processed foods (eG1) and ultra-processed foods (eG4) were composed of the average number of items consumed on each of the three days, and could range from 0 to 33 and from 0 to 23, respectively. The scores were compared using Spearman's correlation, where we expected to see a positive correlation between eGuia and eG1 and a negative correlation between eGuia and eG4. Correlations up to $|0.5|$ were considered weak; $> |0.5|$ a $|0.7|$, moderate; and $> |0.7|$, strong[17,18]. Also part of the convergent validity model, the percentage of individuals placed in the upper quartile of each score according to age group was analyzed. The χ^2 test was used to assess statistically significant differences between prevalence values according to age group for each of the scores.

Invariance analysis

The sample was divided into two subgroups for each variable of interest: sex (female and male); age (≤ 37 and >37, 37 being the sample median); and educational level ($\leq$complete high school and $>$incomplete higher education). Confirmatory factor analysis was used with multiple groups, which makes it possible to verify whether the model maintains its original properties when tested in a stratified manner in subgroups. Three levels

of invariance were tested, where the subsequent level depends on the satisfaction of the previous, less constrained:

1. Configural level, which indicates the equivalence of the factorial structure, that is, the model presents the same factors for both groups tested;
2. Factorial level, which indicates whether the factorial loads of items belonging to each factor are equivalent; and
3. Metric level, which indicates the equivalence of the model intercept and, therefore, if the score generated by the instrument is on the same scale for both groups.

Conclusions can be drawn by observing the variation of goodness of fit indices as the restrictions are inserted in the model[19]. The most recommended indices for invariance analysis studies were adopted: Root Mean Square Error of Approximation (RMSEA), which estimates the fit for the sample, compensating for the model complexity when considering the number of estimated parameters; the Comparative Fit Index, which compares the proposed model to a standardized one; and the Standardized Root Mean Square Residual (SRMR), which is an indicator of the average discrepancy between correlations observed in the sample correlation matrix and correlations predicted by the model. For the configural level, the model was considered adequate when at least two of these criteria were met: RMSEA ≤0.08, SRMR ≤0.10 and CFI ≥0.90, which would indicate the maintenance of the model's original characteristics. For the factorial and metric levels, the difference (Δ) of indicators in relation to the previous, less restricted step was analyzed. The model was considered invariant when at least two of the following criteria were met: ΔCFI ≤0.015; ΔRMSEA ≤0.015; and ΔSRMR ≤0.030 for the factorial level and ≤0.015 for the metric level[20]. All analyses were performed in the RStudio software version 6.4.

Ethical aspects

The study was approved by the Research Ethics Committee of the Public Health School of Universidade de São Paulo (CAAE: 29139220.9.0000.5421).

RESULTS

Most of the 1,309 participants were females (53.0%), had completed high school (65.8%) and reported being white (70.4%). The most prevalent age group was 40–59 years (32.5%) and the region was Southeast (39%). Participants obtained on average 44.1 points on the scale of adherence to guidelines, with eGuia ranging from 14 to 70. The mean score of three days of food consumption was 2.3 for the eG4 (ranging from 1 to 10 .7) and 7.2 for eG1 (ranging from 0 to 20.3) (Table 1).

Table 1. Sociodemographic characteristics of a sample of participants in the NutriNet-Brasil cohort (n=1,309). Brazil, 2021.

Characteristic	n	%
Total	1,309	100
Sex		
Male	615	47.0
Female	694	53.0
Age		
18-29 years	387	29.6
30-39 years	361	27.6
40-59 years	425	32.5
60 years and older	136	10.4
Region		
North	107	8.2
Northeast	317	24.3
Midwest	141	10.8
Southeast	509	38.9
South	235	18.0
Education		
Incomplete elementary school	16	1.2
Complete elementary school	27	2.1
Complete high school	861	65.8
Complete higher education	405	30.9
Race/skin color		
White	921	70.4
Black and brown	364	27.8
Yellow and indigenous	17	1.3
Not reported	7	0.5
Scores	**Mean**	**Standard deviation**
eGuia	44.1	9.1
Planning	13.7	4.6
Food choice	13.5	3.5
Household organization	5.5	1.8
Modes of eating	13.6	3.0
eG4	2.4	1.2
eG1	6.1	3.1

eGuia: score of adherence to the Dietary Guide for the Brazilian Population; eG4: score of consumption of ultra-processed foods, average of three days; eG1: score of consumption of in-natura and minimally processed foods, average of three days.

Table 2 shows that all correlations of eGuia with eG1 were positive and, with eG4, negative (p<0.0001), which is in accordance with expectations. The total eGuia showed a moderate correlation with both consumption scores. By dimension, moderate correlations were seen between planning and eG1, and between food choice and eG4. The other correlations by dimension were weak.

Figure 1 shows the percentage of individuals placed in the last quartile of eGuia, and of eG1 and eG4 according to age group. The probability of being placed in the quartile of greater adherence to the dietary practices recommended by the guide (Q4 of eGuide) tended to increase with age, following the trend of food consumption. According to the χ^2 test, the distribution of quartile classifications differed from the expected if there was no association between the score and age variables (p<0.001 for the three scores).

In the invariance analysis for all subgroups, the model's goodness of fit indices varied within the limits allowed to conclude that the measure is equivalent in different strata of the tested characteristics (Table 3).

DISCUSSION

In this study, the scale of adherence to eating practices according to the Dietary Guide for the Brazilian Population was evaluated in a convergent validation and invariance analyses for subgroups of sex, age and education. As expected, the score on the scale was associated with higher consumption of fresh and minimally processed foods and inversely associated with consumption of ultra-processed foods. Furthermore, the results of the invariance analysis show that the scale is equivalent for different subgroups of the tested characteristics.

Table 2. Spearman's correlation between the score of adherence to the Dietary Guide for the Brazilian Population — total and by dimension — and the scores of consumption of in-natura or minimally processed foods and ultra-processed foods. Sample of participants from the NutriNet-Brasil cohort (n=1,309). Brazil, 2021.

Variables	eG1	eG4
eGuia	**0.591**	**-0.508**
Planning	0.585	-0.370
Household organization	0.264	-0.180
Modes of eating	0.242	-0.225
Food choice	0.423	-0.568

eGuia: score of adherence to the Dietary Guide for the Brazilian Population; eG4: score of consumption of ultra-processed foods, average of three days; eG1: score of consumption of in-natura and minimally processed foods, average of three days. All correlations had p<0.001.
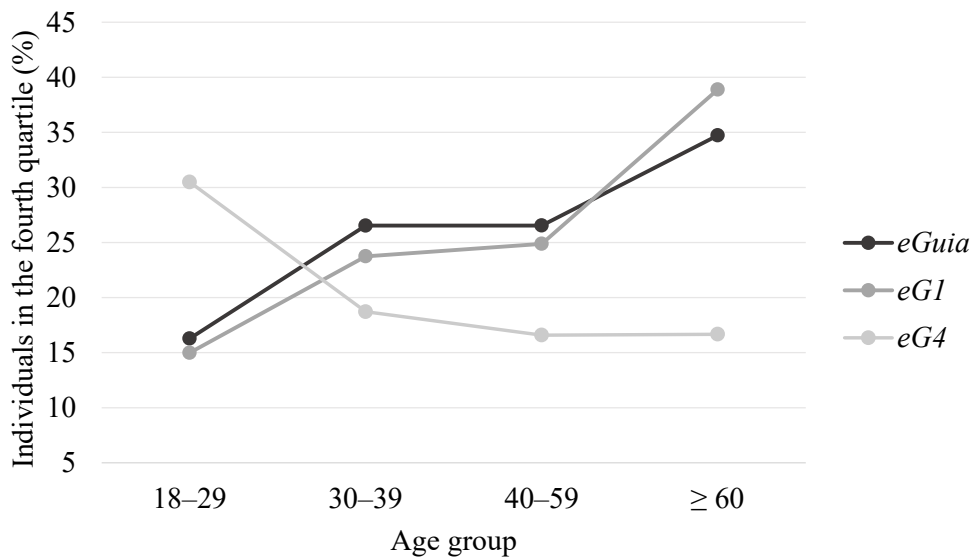
eGuia: score of adherence to the Dietary Guide for the Brazilian Population; eG4: score of consumption of ultra-processed foods, average of three days; eG1: score of consumption of in-natura and minimally processed foods, average of three days.

Figure 1. Percentage of individuals classified in the highest quartile of adherence to the Dietary Guide for the Brazilian Population and consumption (average of three days) of in-natura and minimally processed foods, and of ultra-processed foods. Sample of participants from the NutriNet-Brasil cohort (n=1,309). Brazil, 2021

There is growing evidence of the negative impact of ultra-processed foods on health and the substitution effect that these foods have on dietary patterns based on fresh and minimally processed foods[21,22]. The adoption of indicators based on these two food groups is justified by the golden rule of the guide, which recommends that in-natura and minimally processed foods (predominantly plant-based) and their culinary preparations constitute the basis of the diet, and that ultra-processed foods be avoided[1]. Thus, the direction of the observed correlations is in line with the expected: people with a higher degree of adherence to guidelines consumed more in-natura and minimally processed foods and a less ultra-processed foods.

Although the magnitudes of correlations varied from weak to moderate, according to the paradigm adopted in the guide, healthy eating is not limited to food consumption, but also encompasses the context of meals and the pleasure provided by food[1]. This aspect may explain the fact that the dimensions with the weakest correlations with consumption scores were modes of eating and household organization, precisely the ones whose items are more directly related to the recommendations of chapter 4 in the guide ("The act of eating and commensality"). On the other hand, the dimension with the highest correlation with the G1 score was planning and, with the G4 score, food choice, which contain items directly related to the habitual consumption of foods in these groups and are thus closer to a direct measure of food consumption.

Table 3. Invariance Analysis for sex, age group and years of study of the scale of adherence to the Dietary Guide for the Brazilian Population, using factorial analysis method with multiple groups (n=1,309, Brazil 2021).

	Fit quality indicators						
	RMSEA (90%CI)	ΔRMSEA	CFI	ΔCFI	SRMR	ΔSRMR	Decision
Total sample	0.071 (0.068 – 0.074)		0.922		0.071		
Sex*							
Configural	0.068 (0.065 – 0.071)		0.927		0.074		Accepted
Factorial	0.070 (0.067 – 0.073)	0.002	0.921	-0.006	0.076	0.002	Accepted
Metric	0.073 (0.070 – 0.076)	0.003	0.907	-0.014	0.076	0.000	Accepted
Age group†							
Configural	0.071 (0.068 – 0.074)		0.921		0.076		Accepted
Factorial	0.072 (0.069 – 0.075)	0.000	0.915	-0.006	0.079	0.003	Accepted
Metric	0.072 (0.069 – 0.075)	0.000	0.907	-0.008	0.077	-0.002	Accepted
Years of study‡							
Configural	0.070 (0.067 – 0.073)		0.926		0.075		Accepted
Factorial	0.071 (0.068 – 0.074)	0.001	0.920	-0.006	0.078	0.003	Accepted
Metric	0.070 (0.067 – 0.073)	-0.001	0.915	-0.005	0.076	-0.002	Accepted

RMSEA: Root Mean Square Error of Approximation; CFI: Comparative Fit Index; SRMR: Standardized Root Mean Square Residual. *females and males; †≤37 years and >37 years; ‡≤11 years of study and >11 years of study.

Castelo et al.[23] define "eating practices" as a set of daily routines related to the act of eating, which ranges from meal planning to consumption itself. The structuring of these practices in people's lives is determined by materials and skills such as access to food and cooking skills, and by the meanings attributed to food such as concern with health and pleasure in eating. The practices resulting from the combination of these three elements—materials, skills and meanings—are still influenced by time, space and social context.

Given the multiplicity of factors linked to dietary practices, the correlations found in this work are plausible and corroborated by the literature. Another convergent validation study also found correlations ranging from 0.16 to 0.46 between a score of eating habits and indicators of food consumption among adolescents[24]. Stjernqvist et al.[25] found that a food literacy score explained 41.0% of the variance of another score with a similar construct, health literacy, but only 5.7% of the variance in food consumption score. According to a systematic review by Spronk et al.[26], most studies that investigated the association between knowledge on food and nutrition and quality of food consumption found positive but weak correlations. Although these constructs are not the same as in

this study, they are also not directly observable, but conceptually associated with dietary practices, allowing for comparison.

The performance of eGuia in discriminating age groups similarly to food consumption variables also reinforces its convergent validity. Several studies with populations of different age groups consistently reported a direct relationship between age and food quality. The relative share of ultra-processed foods in total calories tends to be lower—and, consequently, the share of fresh and minimally processed foods tends to be higher—as age increases[27-29]. This is consistent with the results of a previous study carried out with the scale, in which a linear association was found between the score of adherence to guidelines and participants' age[9].

Finally, it was also analyzed whether the measures generated by the scale are equivalent in different sociodemographic groups. Few studies have analyzed the invariance of psychometric measures in the area of food, which makes this analysis one of the strengths of this study. Among the features explored here, sex seems to be the most frequently analyzed in studies of this type: three with this objective were found, and all of them also reported equivalence in the evaluated instruments—scales for addiction to food[30], compulsive eating[31] and eating motivations[32]. No studies evaluating the invariance according to age and educational level of scales related to food were found.

It is worth noting that the choice of variables for invariance studies depends not only on the heterogeneity of the instrument's target audience, but also on the characteristics considered critical to the measured construct[19,33]. The choice of variables sex, age and education in this study lives up to the differences observed in the diet of Brazilians according to subgroups of these characteristics, as shown in a survey that evaluated the prevalence and distribution of healthy and unhealthy eating markers based on the National Health Survey[34]. The study also shows that the variables income and skin color accompany schooling, evidencing their role as an indicator of socioeconomic status. The heterogeneity of the scale's target audience (adult Brazilian population) and the relevance to the context of variables adopted accentuate the importance of the analysis.

This study has some limitations. It is possible that the convenience sample of the NutriNet-Brasil study is composed of people more interested in food and, therefore, does not represent the Brazilian population. However, people with greater interest in the topic are not expected to have different performance in analyses, especially because the factorial structure of the instrument found in this study corroborates a previous work with the same scale, whose sample did not have this same profile[6]. Furthermore, the draw based on quotas by region, sex and educational level aimed to bring the profile of the subsample closer to that of the Brazilian population. Despite this, the inclusion of individuals with a lower level of education was compromised. It is noteworthy that the previous study included people with lower levels of education in the stages of apparent validation and evaluation of the internal structure[6].

Conversely, this investigation makes an important contribution to both national and international literatures. At the national level, the validation of this instrument can boost its use by researchers and public managers across the country for describing the level of

adherence of population groups to the guide, for health promotion activities or for evaluating the impact of interventions, as their temporal stability was tested through test-retest[6]. Although applicable only in Brazil, this study adds knowledge to the growing body of literature about food quality assessment metrics, which has increasingly identified the need for tools that encompass multiple dimensions of food in addition to the already consolidated consumption metrics. This study can also inspire researchers from other countries such as Ecuador, Israel, Peru and Uruguay, which also present non-quantitative recommendations based on NOVA[35], to develop instruments applicable in their contexts.

In conclusion, the scale for the assessment of eating practices according to recommendations of the Dietary Guide for the Brazilian Population has convergent validity, and the score generated by it is comparable between subgroups of sex, age and education. This instrument is, therefore, valid and useful to assess adherence to recommendations and the impacts of local interventions based on it.

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