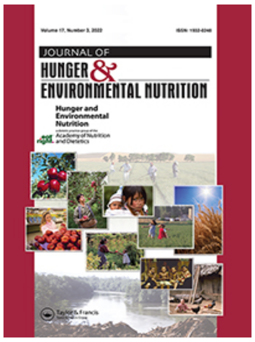

Journal of Hunger & Environmental Nutrition

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/when20

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To cite this article: Francesca Golfin, Carla Murillo, Melissa L. Jensen & Edward A. Frongillo (2022): Adaptation and Validation of the Nutrition Environment Measures Survey in Stores (NEMS-S) in Costa Rica, Journal of Hunger & Environmental Nutrition, DOI: 10.1080/19320248.2022.2088262

To link to this article: https://doi.org/10.1080/19320248.2022.2088262

Published online: 16 Jun 2022.

JOURNAL OF HUNGER & ENVIRONMENTAL NUTRITION
https://doi.org/10.1080/19320248.2022.2088262

Adaptation and Validation of the Nutrition Environment Measures Survey in Stores (NEMS-S) in Costa Rica

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ABSTRACT

This study adapted and validated the NEMS-S in Costa Rica. Twenty-nine food stores were assessed, three times, by two raters. Inter-rater precision and intra-rater stability were quantified. Construct validity was determined with the known-groups method. Relative precision ranged from 0.54 to 0.77 and was 0.87 for total score. Relative stability ranged from 0.58 to 0.96 and was 0.94 for total score. For construct validity, the hypothesized relationship that supermarkets would have the highest scores was supported. The instrument has moderate to excellent precision and stability, has construct validity, and can be useful to develop policies that encourage healthy environments in food stores.

KEYWORDS
NEMS-S; IMANEA; nutrition environment; food stores; food environment

Introduction

Obesity is a main risk factor for the development of chronic diseases, which are responsible for up to 60% of the deaths around the world.[1] Furthermore, many low- and middle-income countries are affected by the burden of malnutrition, and the coexistence of undernutrition, overweight, and obesity.[2] In Costa Rica, according to the National School Weight and Height Census,[3] 34% of children between 6 and 12 years old have overweight or obesity, while the National Nutrition Survey,[4] reports that 60% of women between 30 and 44 years old, and 62% of men between 20 and 64 years old have overweight or obesity.

The pandemic of obesity and chronic diseases is due in part to the increased intake of obesogenic foods and drinks (e.g., high content of sugars and fat).[5] These behaviors are influenced by social, political, and physical environments that affect availability and access to food.[6] Accessibility, price, and variety in food stores influence consumer's food and store selection, contributing to unhealthy eating patterns, less healthy food choices, and high obesity prevalence.[7,8] For example, in adults with obesity and metabolic syndrome, an increase in the consumption of fruits, vegetables, and fiber was associated with a shorter distance to a food store, which was considered healthy.[9]

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Populations that are low-income, segregated, and rural are most affected by low access to healthy foods and high exposure to fast and energy-dense foods,[10,11] which has been positively associated with child obesity.[12,13] Furthermore, higher fruit and vegetable prices are associated with lower consumption in young adults; specifically a difference in the price of fruits and vegetables of one dollar was associated with 32% lower weekly consumption.[14]

In recent years, there has been much interest in assessing and monitoring different elements of the food environment,[15,16] including that of low- and middle-income countries.[17] When assessing associations between food environment exposure, and diet, nutrition, and health outcomes, aspects, such as availability, accessibility, perceived availability, and food vendor choice have been used.[17]

Although literature on the food environment in Latin America has grown in size over recent years, investigations of retail food environments using either adapted and validated or locally developed and validated instruments have been mostly in urban areas of Brazil, Mexico, and Paraguay.[18] Across diverse contexts, results consistently showed lower availability of healthy foods in more disadvantaged neighborhoods, a positive association between the availability of healthy foods and better diet quality (specifically regarding availability and consumption of fruits and vegetables), and mostly null associations between healthier food environments and unfavorable health outcomes and behaviors.[18] Furthermore, the retail food environment in Latin America is similar to North America regarding the strong presence of large supermarket chains and convenience stores, although traditional non-chain channels represent a more important source of food in Latin American countries where there is also a greater heterogeneity within food stores categories.[18]

In 2007, the Nutrition Environment Measures Surveys for Stores (NEMS-S) was developed for use in the United States, to identify the influence of food stores in eating patterns and the increase of obesity.[19] The instrument measures availability, prices, and quality of 10 food categories, and incorporates an application protocol and scoring system. To validate the instrument, 88 food stores (e.g., convenience stores and supermarkets) from four different communities were assessed at three different occasions by two pre-trained raters.[19] By 2016, more than 15 different projects in the United States and countries in South America had used the NEMS-S.[20]

Because the validity of an instrument depends on context,[21] we adapted the NEMS-S to the context of Costa Rica and examined its reliability and construct validity, with the intention of establishing the first construct-validated instrument in the country to assess retail food environments. Specifically, we aimed to examine the inter-rater precision, intra-rater stability, and differences in these by store type, and construct validity.

METHODS

Instrument Adaptation

The study was carried out in nine stages (Figure. 1), from instrument adaptation (stages 1–4) to pilot test (stages 5 and 6) and data collection (stages 7–9). Both first authors (FG and CM), who were fully bilingual (Spanish/English) graduate students at the time of the study, participated in the online NEMS-S training offered by the University of Pennsylvania[22] and translated the original NEMS-S instrument to Spanish. Despite the differences that exist regarding the type of food stores and dietary patterns between developing countries and the United States, we adapted the original NEMS-S instead of an existing adapted instrument from Brazil because the latter included major modifications such as assessing the degree of industrial processing of food as reference for the scoring system,[22] which would make future comparisons with studies using the original NEMS-S difficult.

The adaptation of the instrument was based on the Dietary Guidelines for Costa Rica,[23] in addition to several surveys assessing food and beverage purchase and consumption in the Costa Rican population.[24–26] The adapted instrument, named IMANEA after its Spanish acronym (*Instrumento de Medición del Ambiente Nutricional en Expendios Adaptado*), assessed seven food categories based on the food culture of Costa Rica: milk, fruits, vegetables, whole grain products, meat and processed meats, soft drinks and prepackaged juices, and cheeses (Table 1). In many Costa Rican households, cheese might replace other more expensive animal protein sources (such as beef or chicken) during a main meal. Because of this, and because frozen meals are not part of the food culture, we included a category for cheese and omitted frozen dinners. Furthermore, although eggs are an important source

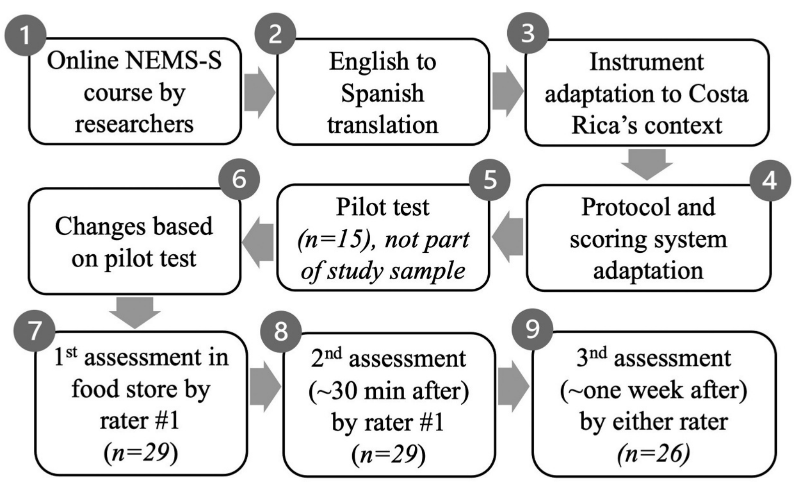

Figure 1. Flow chart diagram of the nine stages through which the study was conducted.

Table 1. Comparison of the food categories included in the Costa Rican adapted IMANEA and the original NEMS-S.

ADAPTED IMANEA	ORIGINAL NEMS-S
1. Milk: nonfat or low-fat	1. Milk
2. Fruits: apple, banana, grape, orange, papaya, pineapple, strawberry, tangerine and watermelon	2. Fruits: apple, banana, cantaloupe, grape, honeydew melon, orange, peach, pear, strawberry and watermelon
3. Vegetables: broccoli, cabbage, carrot, cauliflower, cucumber, green bean, lettuce, squash and tomato	3. Vegetables: carrot, tomato, sweet pepper, broccoli, lettuce, corn, celery, cucumber, cabbage and cauliflower
4. Whole grain products: bread, rice and cookies	7. Baked Goods 9. Bread 10. Baked chips
5. Meat and meat products: chicken, ground beef, Turkey ham	4. Ground beef 5. Hot dog
6. Soft drinks and prepackaged beverages: including diet soda and 100% fruit juice	8. Beverages
7. Cheese: fresh (not included in NEMS-S)	6. Frozen dinners (not included in IMANEA)

of animal protein in the Costa Rican diet, they were not included in the IMANEA because of no healthier version being available. Healthier options of processed foods such as processed meats, soft drinks, prepacked juices, and cheeses were considered as those with lower or reduced content of total fat, saturated fat, added sugar, sodium, and energy density. “Lower” or “reduced” was defined according to the Central American Technical Regulation of Nutritional Labeling[27] as those that contain at least 25% less energy, fat, sodium, or sugar per serving or per 100 g/ml with respect to the reference food. Fruits and vegetables included were those with the highest intake in Costa Rica,[25] starchy vegetables were excluded, as well as vegetables used in small quantities to add flavor to meals (e.g., onion and peppers). Furthermore, we limited the assessment of fruits and vegetables to those consumed fresh (as opposed to canned or frozen). Like the original NEMS-S instrument, IMANEA includes availability and price assessment for all food categories except fruit and vegetables, in which quality is assessed instead of price.

We assessed the nutrition environment in food stores using IMANEA with a protocol adapted from the original NEMS-S protocol. The scoring system was adjusted to match the new instrument; with the total score ranging from −8 to 60 points. Food stores with the highest score (score closest to 60 points) were considered healthier than those with a lower score. We field-tested the preliminary instrument in 15 food stores that were not part of our study sample. As a result, a few minor formatting changes were made to improve instrument clarity. In addition, the pretest revealed that many *pulperías* and *minisúpers* did not have price tags on all products. Therefore, a guideline was added to the protocol stating that, in cases in which a product did not have a price tag, the score for the item would be the same as if the healthier version was more expensive (i.e., so that not displaying price would not give an advantage to the store).

Sample Selection

We sampled three types of stores from La Unión of Cartago, an urban county in one of Costa Rica's seven provinces: supermarkets, *minisúpers* (i.e., which are similar to convenience stores), and *pulperías or abastecedor* (i.e., much smaller food stores that supply basic common foods and beverages). *La Unión* was selected as the location for the study because a previously created database of all food retail establishments (n = 256) of the county from 2015 was available. To be part of this study, the name of the food retail establishment had to indicate at least one of the following: *pulpería, abastecedor, super*, "supermarket," *minisúpers* or be a named food store. Specialized food stores, such as bakeries, farmers markets, and butchery shops, were excluded because they only offered a limited type of food. These criteria reduced the sample frame to a total of 89 food stores. After further exclusion of points of sales due to being in an unsafe area and nonexistence of the store, the final sample consisted of 38 food stores, all of which were visited during data collection. The initial sample size was reduced to 29 food stores because nine stores declined to participate (acceptance rate of 72.3%).

Data Collection

The data collection process followed that described by Glanz et al.[19] Food stores were assessed during three different visits during January and February of 2016 (Figure. 1, stages 7–9), by first authors (FG and CM). The first and second visit were done at least 30 minutes apart from each other and by two different raters. The third visit was done about one week after the first and second visits, by either one of the previous two raters, no important changes were identified in the display of healthy foods in response to the study. Visits consisted of observing and taking notes at the food stores. If a storeowner or administrator questioned the observation being done during the visit, a letter including the study aims, methods, and lack of risk of participation was offered. Of the 29 stores included in our sample, three declined to participate in the third visit.

Data Analysis

Reliability comprises precision and dependability.[28] Precision is the degree to which repeated application of an instrument to the same subject or object, under the same conditions, generates the same results.[28] Dependability is the extent to which differences in the results of applying the instrument consistently reflect actual differences.[28] If no actual differences occur over, say, one week, and the instrument is dependable, then the instrument should give stable results. Test–retest inter-rater precision and test–retest (over one week) intra-rater stability were obtained.

Data collected were entered into a database in Microsoft Excel. Scores were calculated for each food category, as well as a total for each food store and for each visit. The database was imported and analyzed in Stata version 15.0.

Using the data from the three store types together, a three-level linear mixed regression model was used to simultaneously model the differences between the three types of stores and the variation at three levels: among stores within store type, imprecision between raters, and instability over one week within raters. Absolute imprecision and instability were expressed as a standard deviation in the units of the dependent variable (i.e., score) and relative to the variance among stores after accounting for store type.[28] The relative precision was calculated as the intra-class correlation (i.e., the variance among stores divided by the sum of the variances of imprecision and among stores), and the relative stability was calculated similarly. Absolute imprecision and instability are more useful than relative imprecision and instability for quantifying measurement errors and for comparing measurement errors across studies and contexts because the absolute errors are expressed in the units of the dependent variable (e.g., how many points plus or minus in the score) whereas the relative errors are confounded with the underlying variation in the dependent variable.[28]

Construct validity refers to the degree in which the results of a test are related to a theory or an underlying model,[21] and for this study it was determined by the known-groups comparison method.[29] We compared the scores for the three types of food stores, hypothesizing that they would differ in the total score, with supermarkets having the highest score, followed by *minisúpers*, and lastly *pulperías*. Construct validity was determined by the comparison of the mean scores by store to determine if these matched the hypothesized order, using the mixed linear regression model described above and post-hoc pair wise comparisons.

The three-level linear mixed regression analysis with the data from the three store types together assumed that the variation among stores, imprecision between raters, and instability over one week within raters were homogeneous across each of the three store types. To examine this assumption for total score, additional three-level linear random-effects regression analyses were done for each of the three store types separately.

Ethical Considerations

The Scientific Ethics Committee of the University of Costa Rica reviewed and approved this study.

RESULTS

All three measures for each store were completed except three stores that refused the third assessment. *Pulperías* predominated the sample (n = 19), followed by supermarkets (n = 6), and lastly *minisúpers* (n = 4). Assessments lasted between 5 and 23 minutes, depending on the type of store: *pulperías* were the quickest with a mean of 8 minutes (SD = 2.85) and supermarkets the longest with a mean of 15 minutes (SD = 3.25). Table 2 displays the availability of different products by store type as assessed with IMANEA, based on the first visit performed to each store. Overall, *pulperías* had lower availability of items, such as fruit, vegetables, and whole grain products compared to *minisúpers* and supermarkets. Furthermore, the quality of the fruits and vegetables was lower in *pulperías* (data not shown).

Validation results

Inter-rater absolute imprecision was low for each food category and total score (range = 0.85 to 2.82 SD) (Table 3). Intra-rater absolute instability ranged from 0.44 to 1.43 SD across the seven food categories and was 2.01 for total score. Relative precision, quantified as an intra-class correlation, ranged across the seven food categories from 0.54 for milk to 0.77 for whole grain products and was 0.87 for total score. Relative stability, that is, intra-class correlation, quantified as an intra-class correlation, ranged from 0.58 for milk and 0.96 for vegetables and was 0.94 for total score.

Table 2. Number of different products that were available by store type as assessed through IMANEA.

Product category	Pulperías (n = 19)	Minisúpers (n = 4)	Supermarkets (n = 6)	Overall (n = 29)
Milk				
Fat-free milk	16	4	6	26
Fruits				
None	8	1	0	9
Less than four types	9	1	0	10
Four or more types	2	2	6	10
Vegetables				
None	9	1	0	10
Less than four types	4	3	0	7
Four or more types	6	0	6	12
Whole grain products				
Bread	12	4	6	21
Cookies/crackers	17	4	6	27
Rice	1	1	4	6
Meat and meat products				
Fresh meats	2	1	6	9
Luncheon/processed meats	5	3	6	14
Soft drinks and prepackaged beverages				
100% fruit juice	9	4	6	19
Diet or sugar-free soft drink	19	4	6	29
Cheese				
Fresh white cheese	4	4	6	14

Table 3. Reliability of nutrition environment measures expressed as variability among stores within store type, absolute imprecision and instability, and relative precision and stability for each food category and total score (n = 29).

Food category	Possible score	Store (SD)	Inter-rater absolute imprecision (SD)	Relative Precision (ICC)	Intra-rater absolute instability (SD)	Relative Stability (ICC)
1. Milk	[−1, 6]	1.12	1.03	0.54	1.02	0.58
2. Fruits	[0, 6]	1.28	1.17	0.54	0.94	0.72
3. Vegetables	[0, 6]	1.81	1.02	0.76	0.44	0.96
4. Whole grain products	[−3, 18]	2.67	1.46	0.77	1.43	0.72
5. Meat and meat products	[−1, 10]	1.50	1.28	0.58	1.20	0.64
6. Soft drinks and prepackaged beverages	[−2, 8]	1.53	1.26	0.60	0.94	0.81
7. Cheese	[−1, 6]	1.12	0.85	0.64	0.71	0.72
Total score	**[−8, 60]**	**7.27**	**2.82**	**0.87**	**2.01**	**0.94**

Note: Absolute imprecision and instability were expressed as standard deviations (SD) and relative precision and stability were expressed as intra-class correlations (ICC).

Table 4. Mean score by store type for each food category and total score (n = 29).

		Pulperías (n = 19)		Minisúpers (n = 4)		Supermarkets (n = 6)		Pulperías vs Minisúpers	Minisúpers vs. Supermarkets
Food category	Possible score	Mean	SE	Mean	SE	Mean	SE	p-value	p-value
1. Milk	[−1, 6]	2.40	0.41	1.96	0.72	4.57	0.62	0.570	0.003
2. Fruits	[0, 6]	1.15	0.34	3.50	0.74	5.14	0.62	0.004	0.088
3. Vegetables	[0, 6]	1.98	0.45	3.75	0.98	5.81	0.81	0.100	0.105
4. Whole grain products	[−3, 18]	1.69	0.69	4.05	1.35	7.39	1.13	0.107	0.043
5. Meat and meat products	[−1, 10]	0.08	0.49	1.79	0.90	4.37	0.76	0.061	0.022
6. Soft drinks and prepackaged beverages	[−2, 8]	1.50	0.46	3.95	0.90	4.15	0.76	0.012	0.823
7. Cheese	[−1, 6]	0.44	0.28	1.33	0.60	4.68	0.50	0.176	<0.001
Total score	[−8, 60]	9.23	1.74	20.33	3.80	36.07	3.11	0.008	0.001

As hypothesized, supermarkets had highest total scores and scores for all individual food categories (4.15 to 36.07), followed by *minisúpers* (1.33 to 20.33), and *pulperías* (0.44 to 9.23) (Table 4). For the total score, supermarkets were higher than *minisúpers* (36.07 vs. 20.33, $p = .001$) and *minisúpers* were higher than *pulperías* (20.33 vs. 9.23, $p = .008$).

From the analysis of total score for store types separately, variability among stores was lowest for supermarkets and highest for *minisúpers* (Table 5). Imprecision and instability were lowest for *minisúpers* and highest for *pulperías*. *Minisúpers*, which had the highest variability among stores and lowest instability, had the highest relative stability (0.98).

Discussion

This study assessed the precision, stability, and construct validity of IMANEA, an instrument based on NEMS-S to assess nutrition environment in food stores in Costa Rica. Inter-rater precision was assessed by two raters

Table 5. Variability **for total score** among stores, absolute imprecision and instability* and relative precision and stability (ICC) for each store type separately (n = 29).

Store type	Store (SD)	Inter-rater absolute imprecision (SD)	Relative Precision (ICC)	Intra-rater absolute instability (SD)	Relative Stability (ICC)
Supermarkets (n = 6)	3.69	2.50	0.67	1.50	0.93
Minisúpers (n = 4)	8.70	1.84	0.96	1.37	0.98
Pulperías (n = 19)	7.74	3.07	0.86	2.22	0.93

Note: Absolute imprecision and instability were expressed as standard deviations (SD) and relative precision and stability were expressed as intra-class correlations (ICC).

at two visits close together in time. For each of the seven food categories, the inter-rater precision was high, with the standard deviations for imprecision all less than 1.5 points on each food category score and relative precision all above 0.5. Given the larger possible range of the total score (−8 to 60), the variability was expected to also be greater, which resulted in absolute imprecision of 2.82 SD and relative precision of 0.87 for the total score. These results indicate that two different raters were able to go into the same store and closely replicate what each other measured. Our results for relative inter-rater precision were similar to that of the original NEMS-S (i.e., 0.84–1.00)[19] and lower than those from a study conducted in China.[30] Liu *et al* evaluated the store at the same time, as opposed to with a 30-min window, which could have affected the results.

The third visit to the food store, conducted about one week apart from the first two, allowed determination of stability over time. The intra-rater stability was high, with absolute instability less than 1.5 points on each food category score and relative stability all above 0.5. The difference between lower (milk, meat and processed meats, and fruits) and higher relative stability (total score and vegetables) could have resulted for several reasons. First, for milk and processed meats, *pulperías* and *minisúpers* had the products distributed in different parts of the store and in some cases mixed with other products while products with lower sales were on a shelf or freezer. This distribution could have caused a rater to identify only one of the products and not all located in the store, increasing the possibility of measurement error. Furthermore, instability could be observed either because the instrument was undependable, producing inconsistent measurements when no true differences occurred, or because true differences occurred. For example, the latter could have occurred because of lack of periodic restocking, smaller food stores (*pulperías* and *minisúpers*) had large variability in the availability of certain foods, such as milk, fruits, and processed meats. In some cases, mainly *pulperías*, there was only one item available, which could have been easily sold before an evaluator assessed the store.

For assessing construct validity, we hypothesized that supermarkets would have a higher availability, lower prices, and higher quality of healthy products, reflected in the total score, followed by *minisúpers* and then *pulperías*. This hypothesis was verified, showing in part that IMANEA can differentiate between the availability, price, and quality of foods in different types of food stores.

In this study, the adapted version of the instrument was similar to the original NEMS-S in that both assess the availability of healthy products based on their nutrient composition. In contrast, an adapted version of NEMS-S developed in Brazil focuses primarily on the degree of processing of foods, by considering foods with less processing, such as whole-grain products, healthier.[29]

Country-specific food environment instruments are important given that the variety of the food available depends on context. For example, comparison of the NEMS-S with a Guatemalan NEMS-S in Latino food stores found that the US NEMS-S identified a lower number of healthy food options.[31]

This study had several limitations. First, IMANEA excludes specialized food stores used in Costa Rica for food purchases, such as farmers markets, butcheries, and bakeries. Therefore, the instrument cannot be used to determine the entire nutrition environment of a community, district, or larger administrative area. For example, walkability was not taken into consideration when assessing stores. Supermarkets could have higher product availability and scoring, but transportation might be a barrier for their use.

Second, the county from which stores were sampled was urban, and differences might exist from rural areas in Costa Rica. Sociodemographic characteristics of *La Unión* are comparable to those seen nationwide, however, in terms of education level (46% at least high school compete vs. 39% nationwide), internet access (47% of households vs. 34% nationwide), and economic status (8% households with insufficient resources vs. 11% nationwide).[32]

Third, we included smaller *pulperías* which would be attended by consumers with low socioeconomic status when transportation was a barrier. The types of stores studied are found in most of Costa Rica's rural settings, including coastal and mountainous towns, but may not be typical in indigenous territories or extremely remote areas.

Implications for Research and Practice

The IMANEA represents the first adapted and validated instrument designed to measure the nutrition environment in food stores in Costa Rica. In the future, it could be used as an instrument to provide information to help promote the development of health actions and policies that encourage the improvement of these environments. Furthermore, IMANEA could complement instruments that assess food security, and it could be used as a reference in other developing countries, to promote research in this topic.

Given the importance of the food environment as a major contributor to diet,[33] future research should address other aspects such as food composition (i.e., changes in critical nutrients such as added sugars and sodium), food labeling, food marketing (including digital and in retail settings), and food prices, to name a few. This research could inform the successful design, implementation, and future evaluation of policies seeking to improve the food environment and long-term population health outcomes.

Acknowledgments

We thank the owners and administrators of the food stores that participated in our study. Also, a special thanks to Dr. Anne Chinnock and MSc. Johnny Cartín, who provided insights in the preliminary stages of this work; and to Dr. Xinia Fernández, who shared the list of food stores of *La Unión* in *Cartago*, that served as our sampling frame.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

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