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Methodological aspects in the food consumption assessment of pregnant women in the Multicenter Study of Iodine Deficiencys

Aspectos metodológicos na avaliação do consumo alimentar de gestantes no Estudo Multicêntrico de Deficiência de Iodo

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ABSTRACT

Objective
To describe in detail the methodological aspects used in the assessment of food consumption of pregnant women within the Multicenter Study of Iodine Deficiency to streamline the reproducibility of this work and other studies.

Methods
The 24-hour dietary recall (24hR) was used to assess pregnant women's dietary intake (n=2,247) in a nationwide sample. The method was adapted for paper application, followed by data entry in the GloboDiet software. Subsequently, the data were verified for inconsistencies and submitted to quality control (e.g., Goldberg analysis). Foods were also categorized under the NOVA classification and food groups.

Results
Several challenges were observed in the study: adaptation of the paper format-based data collection for the software data entry and the lack of iodine data composition. However, some potentialities of the collected data stood out, including the standardized, detailed collected data and the types of dietary indicators that can be generated from the created databases.

Conclusion
We expect the shared information to favor data harmonization and, therefore, enable the comparison of evidence generated among Brazilian studies.

Keywords: Iodine. Methods. Nutrition surveys. Pregnant women.

RESUMO

Objetivo

Descrever com detalhes os aspectos metodológicos utilizados na avaliação do consumo alimentar de gestantes no Estudo Multicêntrico de Deficiência de Iodo para otimizar a reprodutibilidade deste e outros estudos.

Métodos

O Recordatório 24-horas foi utilizado como ferramenta para a avaliação do consumo alimentar de gestantes (n=2.247), em amostra de abrangência nacional. O método utilizado foi adaptado para aplicação no papel, seguido pela inserção dos dados no software GloboDiet. Em seguida, procedeu-se à verificação de notas de inconsistência e controle de qualidade dos dados (por exemplo, análise de Goldberg). Os alimentos também foram categorizados conforme a classificação NOVA e por grupos alimentares.

Resultados

Vários desafios foram observados na avaliação do consumo alimentar: adaptação da coleta no papel para entrada de dados no software, falta de composição de dados de iodo, dentre outros. Não obstante, destaca-se a padronização e detalhamento de dados coletados e gerados, bem como os tipos de medidas dietéticas que poderão ser geradas a partir dos bancos criados.

Conclusão

Acredita-se que o compartilhamento dessas informações pode favorecer a harmonização de dados dietéticos, bem como a comparação das evidências geradas entres os estudos brasileiros.

Palavras-chave: *Iodo. Métodos. Inquéritos nutricionais. Gestantes.*

INTRODUCTION

Monitoring food consumption plays a vital role in population studies on maternal and child health [1], as it provides fundamental information that can guide public policies to identify, improve, and intervene in determinants of health and the well-being of this population. The usual consumption of foods and nutrients and their prevalence of inadequacy stand out [2] among the several nutritional indicators generated in monitoring food consumption.

Although dietary data is essential for evaluating and monitoring the eating habits of individuals and populations, we need more reliable methodologies to ensure these data's comparability on a global scale [3,4]. In this context, the 24-hour dietary recall (24hR) stands out as a method for assessing self-reported food consumption, which provides more accurate estimates at the individual level and information about the distribution of dietary intake in a given population [5].

Methodological details are often omitted in food consumption assessments, compromising the internal and external validity of the studies. Although there are current recommendations to guide the description of food consumption assessment in scientific research reports [6], the non-uniform, unclear, or incomplete presentation of food intake data restricts interpretation, usefulness, and comparisons between studies [7].

When presenting and interpreting food and nutrient consumption data, we should consider the assessment's objective, the data collection method, how food items were grouped, and decisions related to reporting recipes and additions during preparation and processing, besides the inherent limitations of food databases [7]. A careful description of the method and its limitations is vital for correctly interpreting the results [6].

The *Estudo Multicêntrico de Deficiência de Iodo* (EMDI, Multicenter Study of Iodine Deficiency) aimed to evaluate the prevalence of iodine deficiency and the factors associated with the nutritional status of Brazilian pregnant women, including the assessment of food consumption, and we decided to adopt the 24hR for data collection. Furthermore, considering the multicentric nature of the

study, the different approaches to assessing food consumption by the institutions involved in EMDI, and the challenge of capturing Brazilian dietary diversity and variety, we identified the need for standardization and centralization in food consumption data assessment, aligned with practices observed in other population studies, such as the MOBA study [1].

This article aims to describe in detail the methodological aspects used in evaluating the food consumption of pregnant women in the Multicenter Iodine Deficiency Study to streamline the reproducibility of this work and other studies.

METHODS

Study design, population, and sampling

The EMDI is an epidemiological, observational, cross-sectional and probabilistic sampling study conducted in 11 Brazilian municipalities, at least one in each macro-region of the country (Alegre-ES, Aracaju-SE, Brasília-DF, Belo Horizonte-MG, Macaé-RJ, São Luís-MA, Palmas-TO, Pinhais-PR, Ribeirão Preto-SP, Rondonópolis-MT, and Viçosa-MG), with the involvement of 14 higher education institutions.

The study population consisted of pregnant adult women (over 18) who received prenatal care in the Unified Health System in one of the *Estratégia Saúde da Família* (ESF, Family Health Strategies) in the mentioned municipalities. Pregnant women with a history of thyroid disease or surgery, self-reported diagnosis of hypothyroidism, pre-existing hypertension, or hypertensive pregnancy disorders were excluded due to the multicenter study's objectives.

The sample size was initially estimated at 2,926 pregnant women cared for by the ESF teams, using a minimum proportion of 8%, with a relative error of 50%, 95% confidence level, and a 1.5 design effect, resulting in 266 women in each research center (from now on "center"). The selection of pregnant women adopted the two-stage cluster sampling technique, using the ESF as primary units and the pregnant women within them as secondary units. The mean number of pregnant women cared for monthly in each PHC Unit (*Unidade Básica de Saúde*, UBS) was estimated after the territorial organization of the ESF units for the municipalities. The list of pregnant women monitored monthly served as the basis for recruitment, with a draw to compose the sample quotas for each UBS. The final sample totaled 2,659 pregnant women due to collection difficulties and the COVID-19 pandemic, of which some did not collect food consumption data.

Data collection, instruments, and techniques used

Data were collected following approval by the Research Ethics Committees of each collaborating institution (Federal University of Viçosa, CAAE: 80172617.0.1001.5153). This procedure was conducted by field teams comprising previously trained undergraduate and postgraduate students.

Data collection started in September 2018 and continued until March 2020 in all the municipalities. Brasília (DF), Belo Horizonte (MG), Rondonópolis (MT), Aracaju (SE), and Palmas (TO), however, resumed field collections between January and April 2021, as this stage was interrupted due to the social distancing measures imposed by the COVID-19 pandemic.

Data collection with participants consisted of face-to-face interviews in the waiting room of the UBSs and sometimes in the homes of pregnant women previously identified in the ESF.

Besides food consumption data, socioeconomic, demographic, environmental, and health data were collected using a semi-structured questionnaire and the data management platform REDCap (Research Electronic Data Capture) [8].

Food consumption data were collected by applying the 24hR print form employing the Multiple Pass Method, in which the respondent's food consumption was questioned in chronological order from the moment women woke up on the previous day. We decided to apply a second 24hR in a subsample of the study to correct intraindividual variability in food intake estimates. The form adopted was explicitly created for the study, adapted from the traditional 24hR to enable its application on print format and subsequent data entry in the GloboDiet software [9].

This adaptation was based on similar experiences with entering food consumption data in the software [10,11]. The adapted 24hR reflected data entry in the software regarding the recalled day, special day/diet, time, occasion and place of consumption, processing, brand, preparation method, type, and flavor of the food. We underscore some possible answers for the detailed description of the food and drinks consumed: Unknown (UK) or Not applicable (NA) options were incorporated to record the participants' reports more precisely. This form also enabled detailed recording of the use of salt, the fat type, other additions to preparations consumed, and details of recipes.

The Photographic Manual [12] with food portions and household measurements was used to assist in quantification. Participants quantified food consumption using standard units and portions or estimated in grams and ml directly, if they knew how.

Field team members received support materials during the data collection period, such as instructional videos on dietary data collection and a list of Probes for 24hR detailing (available in: https://www.gupea.ufpr.br).

Processing the data on food consumed by pregnant women

The 24hRs were entered in the GloboDiet software, Brazilian version [9], Data Entry mode. Digitized copies of the 24hR collected at each center were sent to the Dietary Exposure Group Assessment from the Federal University of Paraná, responsible for centralizing consumption data for processing and analysis.

Once entered, the 24hR underwent a data consistency analysis. For this purpose, GloboDiet generates a file called NOTES, which details inconsistencies automatically generated in 24hR or included by the data entry person (e.g., amounts not reported, excessive amounts, information pertinent to evaluations recorded by the interviewers).

Notes were processed following the guidelines in the "Manual for standardizing the treatment of GloboDiet notes" (available in https://www.gupea.ufpr.br) and per the specificities of each center. The main recommendations were to treat notes referring to unknown or excessive consumption amounts, inadequate use of the food quantification manual, and new foods/recipes created during data tabulation.

Other decisions were necessary for notes related to the amounts consumed. In some cases, the amount reported as missing was related to another food, such as butter/margarine. In these situations, the algorithm provided by GloboDiet was used to estimate the amount of butter/margarine proportional to the bread consumed. In other cases, the ISA Study critique manual [13] or the Household Measurement Table from the 2008/09 Family Budget Survey [14] were adopted to make decisions.

Regarding sugar, study interviewers were trained to describe and measure foods, including ingredients, separately in the 24hR. However, some foods were eventually described together, particularly for some sweetened beverages. These drinks were then linked to sugar composition data. When this was not possible due to the lack of an exact link, an extra line was added to the database to quantify sugar at a proportion of 5% of the volume ingested (n=15). This data management generated the weight of each food consumed that day.

Nutritional components of the evaluation

The nutritional components initially evaluated in the EMDI include estimated energy (kcal) and nutrients (protein (g), carbohydrates (g), lipids (g), fiber (g), sodium (mg), potassium (mg) and iodine (mcg)), besides the FAO/WHO food groups (n=19) and subgroups (n=82) used for standardization and made available on the FAO/WHO GIFT platform [15], and the NOVA classification groups (unprocesssed or minimally processed, food ingredients, processed, and ultra-processed foods [16].

Foods and preparations were linked mainly to composition data from the *Tabela Brasileira de Composição de Alimentos* (TBCA, Brazilian Food Composition Table) [17] and the *Tabela de Composição de Iodo nos Alimentos* (TCIA, Iodine Food Composition Table) [18] at the food and recipe ingredient level. While the TBCA was chosen because it is a compilation of analytical data on foods consumed by the Brazilian population, the TCIA is a product of the work of EMDI researchers and was created due to the lack of information on the iodine content of foods in national food composition tables.

Missing data or traces in the composition of foods from TBCA were treated as zero. The contents of similar foods or labels were used for foods not found to match this reference. For iodine, other food composition tables were consulted [19-23] when the content was not found in the TCIA, and when not identified in these tables, they were treated as missing values. The researchers conducted the identification of its correspondent in the composition tables in pairs, and inconsistencies in choosing the best match were discussed. Moreover, water samples from the Health Units in each municipality and salt samples were also collected to determine iodine concentrations, allowing us to complement the data on these foods.

Considering that the linkage of foods with the proximate composition was not perfect for all foods reported in EMDI, a classification system for data linkage was created: "Exact", "Almost exact" (minor differences usually referring to the method of preparation or a specific type of food), "Similar" (different but close food) and "Labels".

Foods were classified at the level of disaggregation of foods and recipe ingredients by pairs and corroborated by the centers. Considering the possible specificities for the NOVA classification of foods, researchers from each center were contacted to clarify possible doubts about the classification.

For example, cheese bread in Aracaju consists of a different preparation than in other centers and, therefore, contact with local researchers at that center was essential to classify this item as processed, whereas, in Curitiba, it was assumed to be the most common consumption of frozen cheese bread, which may contain food additives, classifying this item as ultra-processed.

The NOVA classification was initially conducted by adding a fifth category called "uncertain" to avoid the unspecified allocation of food in a specific group due to the lack of detail provided in the recall, per the guidelines on the website https://www.gupea.ufpr.br. For example, White bread is not specified as to type or brand.

Data quality control: criteria and decisions

Quality control of EMDI food consumption data was comprehensive throughout the study, from planning to data collection and entry. It included team training, double-checking of data, and other data processing measures. Moreover, specific investigations were performed on the intake of certain foods, such as rice and beans, which should be registered as recipes to consider the ingredients typically used in preparation by the Brazilian population (including salt and oil); powdered foods, which could be consumed alone or reconstituted with water or milk; and raw foods, which should be registered as ready-to-eat.

Extreme values in the daily consumption of food groups and nutrients by participants and the number of food items reported were inspected at the end of linkage with nutritional information and food classification. Paper-based 24hR forms with energy intake below 500 Kcal/day or above 4000 Kcal/day [24] and less than five reported foods were inspected for biological plausibility. Forms with plausible justification were maintained, such as low consumption attributed to nausea or vomiting, reports of excessive appetite, or greater consumption due to an atypical day.

Goldberg's analysis [25] was performed to evaluate the probable degree of bias in energy intake reported at the population level in EMDI-Brazil. The following parameters were assumed to calculate the cutoff point [26]: physical activity level equal to 1.4, multiplied by the Basal Metabolic Rate (BMR), as recommended by Prentice et al. for pregnant women [27]; 95% confidence interval; intrapersonal coefficient of variation in intake of 23.0%; coefficient of variation for BMR measurements of 8.5%; total coefficient of variation for physical activity level of 15%; and number of evaluation days equal to 1, as not all pregnant women had two 24hR days. The Schofield formula [28] was considered to estimate BMR based on pre-gestational weight and with additional energy expected for each gestational trimester (85, 285, and 475 kcal, respectively) [29].

Analyses were conducted using IBM®SPSS® version 22 software. Means and 95% confidence intervals (95% CI) were calculated for continuous variables, while absolute (n) and relative frequencies (%) were estimated for categorical variables.

RESULTS

Twenty-eight typists, including undergraduate and master's students, previously trained to interpret 24hR and use the software, participated in entering 24hR in the GloboDiet. On average, each recall entry lasted 23 minutes (95% CI: 22-24).

The EMDI-Brazil collected 2,659 eligible 24hR, and recalls without plausible justifications were excluded from the analyses (n=52). The collection of the first 24hR was 2,247, and the second 24hR was 412, representing 18.3% of the sample. Variations were observed between centers (Table 1). The interval between the first and second 24hR was an average of 26 days (95% CI: 22-29).

Food consumption data collection included different seasons and days of the week (Table 1), which occurred heterogeneously between the centers and Health Units, reflecting different logistical challenges in field research in each center: approval by the ethics committee to start the research, the availability of pregnant women in the health units on specific days, and recruitment difficulties in some venues, such as, for example, the lack of prior identification of pregnant users. These aspects will be considered and incorporated into the statistical analysis to adjust for center differences.

Table 1 – Distribution of 24-hour recalls by research center, day of the week, and season of the year in the EMDI-Brazil.

Variable	24hR included		24hR included per collection day				24hR excluded	
	Total		First		Second		Total	
	n	%	n	%	n	%	n	%
Center								
Aracaju	358	13.5	263	11.7	95	23.1	8	15.4
Belo Horizonte	204	7.7	182	8.1	22	5.3	5	9.6
Brasília	151	5.7	143	6.4	8	1.9	1	1.9
Macaé	259	9.7	218	9.7	41	10.0	1	1.9
Palmas	115	4.3	90	4.1	25	6.1	2	3.8
Pinhais	326	12.3	273	12.1	53	12.9	4	7.7
Ribeirão Preto	304	11.4	261	11.6	43	10.4	7	13.5
Rondonópolis	247	9.3	219	9.7	28	6.8	5	9.6
São Luís	342	12.9	292	13.0	50	12.1	6	11.6
Viçosa	304	11.4	260	11.6	44	10.7	12	23.1
Vitória	49	1.8	46	2.0	3	0.7	1	1.9
Total	2659	100	2247	100	412	100	52	100
Season of the year								
Summer	664	25.0	566	25.3	98	23.1		
Autumn	762	28.7	625	28.0	137	32.3		
Winter	611	23.0	501	22.4	110	26.0		
Spring	622	23.3	543	24.3	79	18.6		
Day of the week								
Sunday	131	4.9	112	5.0	19	4.5		
Monday	390	14.7	349	15.6	41	9.7		
Tuesday	619	23.3	534	23.9	85	20.0		
Wednesday	629	23.6	540	24.2	89	21.0		
Thursday	534	20.1	418	18.7	116	27.4		
Friday	313	11.8	250	11.2	63	14.8		
Saturday	43	1.6	32	1.4	11	2.6		

Table 2 summarizes the main notes generated and the corresponding data processing recommendations. After this management, only notes classified as "missing value to be filled in later" remained, which were defined in the study as dependent on the imputation of median values, calculated based on the consumption of the group of pregnant women in each center. We considered whether the food item was consumed as food or an integral part of a recipe for this imputation. An exception was established when the same food had already been consumed and reported by the respondent in the 24hR. In these cases, the previously reported value was imputed.

Of a total of 7935 unique foods reported, 59.9% of the foods were linked to the TBCA proximate composition considered "Exact", 37.0% "Almost exact", 2.2% "Similar", and 0.9% included information from food labels. Among the "Almost exact" linkages, the report of the food consumed with a generic description, hindering a more precise composition choice, occurred in several cases. For example, "Pumpkin, unspecified, cooked" was linked to the composition of "Pumpkin, neck, unskinned, seedless, cooked, drained, without oil, with salt", although it is not sure whether this was the case, the type consumed, and even less if it did not have skin and oil or if salt was added. Foods categorized as "Similar" required better evaluation for linkage; using a similar food as an example, Yacon Potato was linked to Sweet Potato. Regarding iodine data, 58.8% had an "Exact" linkage, 24.2% "Almost exact", 13.6% "Similar", and 2.8% had no linkage at all.

Table 2 – Notes of inconsistencies and conduct for processing food consumption data. Estudo Multicêntrico de Deficiência de Iodo, Brazil, 2020.

Note type	Note Description	Definition	Conduct	Example
G	General	24hR information note	Helpful information when making decisions related to notes of the following types: SPE, UNK, OVER, NEW_F, NEW_R, I_ADD, and I_DEL	Pregnant woman with nausea or pregnant woman did not eat lunch
G_DT	Special diet report	Special diet information note	Useful information in data quality control	Diet for hypercholesterolemia or diabetes
G_DY	Special day report	Special day information note	Useful information in data quality control	Out of routine or detected nausea
SPE	Note specific to any food item	Information note that could be generated regarding any item reported in the 24hR (e.g., occasion of consumption, food, ingredient...)	Helpful information when making decisions related to notes of the following types: UNK, OVER, NEW_F, NEW_R, I_ADD, and I_DEL, and while checking the entry of the food item where there was doubt regarding the action taken by the data entry person	Peach size not specified in the recall. In this case, the note informs that the imputation is necessary for the peach amount
UNK	Unknown amount	Note generated when the amount was zero	For foods with unknown or incomplete quantities, values were imputed	The same amount was imputed if the food consumed with a missing amount had already been consumed. The median consumption value of the group per center was imputed for amounts without previous solution
OVER	Excessive amount	Note generated when the amount exceeded expected values for food consumption	The amount was checked in the 24hR on paper to check for possible typing errors, besides checking for consumption plausibility	Consumption of 3000g of water/day or 4 medium ladles of beans
NEW_F	New food created	Note generated when a new food was created	New foods were searched once again in the software to ensure they were new	Cuxá and Pitaia received new codes
NEW_R	New recipe created	Note generated when a new recipe was created	New recipes were searched once again in the software to ensure they were new	Potato pierogi, cheese, and Vinaigrette received new codes
I_ADD	Ingredient added to the recipe	Note generated when an ingredient had been added to the recipe	Confirming the ingredient's plausibility in the recipe	Adding bell peppers to a tomato sauce recipe. Informational note only

Regarding the FAO/WHO classification, only two groups were not reported: 1) insects and grubs and 2) food supplements, which were not collected in the evaluation. As for food subgroups, 21 subgroups out of 82 were not reported. These include foods more common in other food cultures or less likely to be consumed by pregnant women, such as millet, sorghum, and foods for sports purposes.

Around 74% of the foods reported by pregnant women were classified into one of the four NOVA groups. However, 25.9% of the foods were classified in the "Uncertain" category before the final classification of the foods.

The mean ratio between reported energy intake and basal metabolic rate was 1.31, below the confidence interval estimated with the Goldberg method (1.53-1.57), giving a general energetic underestimation in the sample studied at the population level. The probable energy underestimation was 22.4% at the individual level.

DISCUSSION

This article described the collection and analysis of data on the food consumption of pregnant women in the context of the EMDI-Brazil study. Biologically plausible 24hR were collected from 2,247 pregnant women, covering different periods of the year and days of the week, with variations between research centers due to logistical challenges.

The different care settings for pregnant women in the Health Units studied highlighted the difficulty of more effective monitoring of 24hR collection, which was also hampered by the COVID-19 pandemic, which affected the data collection conclusion. The foods were analyzed for composition

and classification, with around 25.9% of the foods initially categorized as "Uncertain" for the NOVA classification. Furthermore, energy intake underestimation in the sample was observed.

The details presented reflected several challenges in assessing food consumption, including paper collection with data entry into the analysis software. The need to collect from paper-based forms was due to the lack of notebooks and licenses available for using GloboDiet by research teams. This option made the research viable but also brought challenges, such as difficulties in monitoring the application of the 24hR, which would have been easier with a computerized method [30]. It also resulted in a significant post-data collection workload prone to typing errors, which we hope was minimized with the quality controls adopted [31]. Furthermore, this situation highlights the lack of access to reliable computerized methodologies to assess population food consumption at the individual level in Brazil and other countries [4,32].

Failure to validate the paper-based 24hR form may raise concerns. However, the form used in this study was adapted from successful experiences in other locations [10,11]. These adaptations have provenly improved the accuracy of information recording, primarily regarding frequently omitted details, such as place of consumption or generic food descriptions. For example, when participants could not provide specific details about consumption, the "Unknow" option was made available, reducing uncertainty about information not included in the 24hR. Furthermore, the standardization or revision of the 24hR is knowingly beneficial in some studies [33].

Linking food composition data evidenced advantages and challenges in assessing EMDI food consumption. On the one hand, a significant part of the food was not precisely linked. However, linking the data after collection, instead of using software with a pre-defined composition, has knowingly improved the quality of food composition data, per international recommendations [34]. Furthermore, foods with non-exact linkages were submitted to TBCA coordination and recently updated in their database [17], making them available for other studies. The impact of the composition of these foods on EMDI analyses will be examined shortly. Furthermore, although the compilation of iodine composition data may be incomplete for some foods, this table represents a scientific advance in studying iodine. It is the first Brazilian initiative in this field.

Opting for the FAO/WHO and NOVA classification for grouping foods seeks to present data internationally harmonized to achieve data comparability between studies and countries [15], promoting the study's external validity. In this sense, these indicators contribute to more accurate estimates of the food groups consumed by Brazilian pregnant women globally. For example, fruit juices are not considered as fruit, but as non-alcoholic drinks. The classification of the processing level depends on the detail provided (for example, whether the product is natural or industrialized, preferably defined by the list of ingredients).

Concerning the level of uncertainty observed in the NOVA classification, we expect to have contributed to the transparency of the evaluated data. Food items that can be assigned to more than one NOVA group are a challenge in the evaluation [35]. In this sense, sensitivity analyses can be performed to determine these uncertainties' impact on the NOVA groups' estimates and their associations with the results in future assessments [16].

Although energy underestimation is a well-known challenge in population studies using self-reporting methods, studies that apply these cutoff points to identify under- or overestimated food consumption, especially in pregnant women, are rare [1]. Indeed, no assessment method is error-free, and underestimation should be recognized as a limitation in all future assessments of food consumption data in the EMDI study. Whenever possible, sensitivity studies can also be conducted to

assess the impact of estimates from pregnant women that are underestimated. However, excluding these pregnant women is not recommended, given the lack of precision in estimating BMR [1,26].

This is the first nationwide study evaluating the food consumption of Brazilian pregnant women, with data collection at the individual level. It will provide data on nutrient and food intake distribution and the prevalence of inadequacy. In a standardized, detailed, and harmonized way, the databases generated between the centers will diagnose other food consumption indicators, such as times and places of consumption, minimum dietary diversity, and dietary pattern analyses. We expect this assessment to improve public food and nutrition policies to solve the main nutritional problems related to pregnant women in the country, especially iodine, and streamline the reproducibility of other studies.

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