

### RESEARCH ARTICLE

## Development of a mobile application to assess Brazilian schoolchildren's diet: CADE – food consumption at home and at school

Jade Veloso Freitas<sup>1,2\*</sup> , Sandra Patricia Crispim<sup>3</sup>  and Marina Campos Araujo<sup>1</sup> 

<sup>1</sup>*Sergio Arouca National School of Public Health, Oswaldo Cruz Foundation, Ministry of Health, Rio de Janeiro, RJ, Brazil*

<sup>2</sup>*Department of Epidemiology, Institute of Social Medicine, State University of Rio de Janeiro*

<sup>3</sup>*Department of Nutrition, Federal University of Paraná, Curitiba, Brazil*

(Received 18 November 2021 – Final revision received 11 March 2022 – Accepted 14 March 2022)

*Journal of Nutritional Science* (2022), vol. 11, e27, page 1 of 9

doi:10.1017/jns.2022.25

### Abstract

The development of technologies for children's dietary assessment shows important potential for reducing the occurrence of inherent errors in traditional methods. The present study aimed to describe the development of a mobile app for the dietary assessment of Brazilian schoolchildren. The mobile app assesses schoolchildren's diet with self-report by their parents or guardians in the home environment, through multiple-pass 24-hour recall coupled with a food propensity questionnaire; and by an adult in the school environment, through a food record. The tool presents a database of food items usually consumed by Brazilian schoolchildren, including modes of preparation, probing foods and types of food quantification such as digital photos of household measurements and food portions. The CADE app (food consumption at home and at school) contains 2125 food items, 9 options for preparation methods and 18 options for probing items. There are 75 options for household measurements, also including 26 digital photos of four types of household measurements and 440 photos of portion sizes of 90 foods from the Brazilian Manual of Child Food Portion Quantification. Some innovative features include an interface to take photos of the child's meals and report seconds and leftover food consumption, besides the possibility of receiving notifications on the mobile device to remember to report the diet. The CADE app can assist the standardisation and automation of dietary data collection from schoolchildren, support food and nutrition data in childhood and promote research in nutritional epidemiology while reducing data collection costs.

**Key words:** Food consumption: Mobile application: Schoolchildren: Technology

### Introduction

Low-quality diet is now known to be the main risk factor (exceeding smoking and high blood pressure) for morbidity and mortality from chronic non-communicable diseases<sup>(1)</sup>. Adequate nutrition is critical for healthy growth and development in the early years of life<sup>(2)</sup>. Inadequate nutrients' intake can harm the nutritional status in childhood and later ages<sup>(3)</sup>. Brazilian data from a systematic review published in 2015 found that the food consumption of school-age children was marked by high frequencies of inadequacy in nutrients' intake, mainly iron (22–40%), vitamin A (20–59%) and zinc (20–53%)<sup>(4)</sup>. This recognition has encouraged studies to assess

dietary intake and to improve methods for estimating individuals' diet<sup>(1)</sup>. Dietary assessment in childhood is important, since it is a stage of life in which eating habits are developed, crucial for the promotion of healthy eating throughout life<sup>(2)</sup>. However, assessing schoolchildren's dietary intake is not simple, especially because their cognitive skills may not be fully developed. Depending on their age, children's ability to identify and remember the foods they have eaten and to describe cooking or other food preparation methods is limited<sup>(1,5,6)</sup>. There is also difficulty in estimating the amounts consumed<sup>(7)</sup>.

Dietary assessment methods are subject to systematic errors, affecting the estimated validity<sup>(8)</sup>. Some memory-

\* Corresponding author: Jade Veloso Freitas, email [jadevfreitas@gmail.com](mailto:jadevfreitas@gmail.com)



dependent tools, such as the 24-hour recall (24-HR) and food-frequency questionnaire, are more subject to underreporting than others. On the other hand, the food record (FR) can change eating habits depending on the evaluation<sup>(9)</sup>. The recommended methods for assessing children's dietary intake vary according to age and the person reporting<sup>(10,11)</sup>. A systematic review found that the 24-HR reported by parents of children aged 4–11 years obtained higher accuracy when compared to double-labelled water<sup>(10)</sup>. Studies indicate that the 24-HR with the automated multiple-pass method (AMPM) using a technological tool is the best option for this age group<sup>(12,13)</sup>. However, direct observation and/or the FR with or without weighing has often been used to assess children's food dietary intake in school<sup>(10,13–16)</sup>.

Recent decades have seen the advent of new technologies for dietary assessment<sup>(17)</sup>. Studies have demonstrated the advantages of these technological tools in relation to the collection of data in paper format<sup>(18,19)</sup>; optimisation and real-time availability of results<sup>(20)</sup>; reduction of costs and time in data collection<sup>(21)</sup>; improvement of participants' motivation in the interviews; and mainly minimisation and prevention of errors associated with dietary report, thus improving the estimates' validity<sup>(22)</sup>.

Systematic reviews published in the last 5 years on the development or validation of technologies<sup>(21,23,24)</sup> identified twelve studies on the development of technologies to investigate schoolchildren's diet<sup>(16,25–39)</sup>. Web-based 24-HR is the most frequently applied technology in this age group<sup>(27,30–33,35,37)</sup>, but tools have also been developed that are based on mobile devices such as smartphones and tablets<sup>(26,36,38,39)</sup>. Most of these technologies were developed for North American and European schoolchildren<sup>(16,25–27,30–34,37–39)</sup>. These systematic reviews found only one technology that was developed and validated in Brazilian schoolchildren, consisting of a qualitative dietary assessment of children aged 7–10 years through a web-based questionnaire on the previous day's diet<sup>(28,29)</sup>, hindering the accurate estimation of food amount and energy and nutrient intake. We also found an offline mobile app for tablets used in the 2019 Brazilian National Survey on Child Nutrition (ENANI), which investigated dietary intake in children under 5 years of age<sup>(40)</sup>. However, older children are known to have more autonomy over their food intake. So, the children's participation in food intake assessment in the school environment is essential, aspects that have not been investigated in other Brazilian technologies<sup>(28,29,40–44)</sup>. Furthermore, the use of technologies developed for different age groups<sup>(41,44)</sup> to school-age children is limited.

Developing a technological tool that allows investigating the food consumption of Brazilian school-age children in a standardised and automated is important. It is crucial to know food intake in different children's environments, estimate children's diet qualitatively and quantitatively, and capture the cultural diversity of their food intake. The present study design was descriptive and aimed the development of a mobile app to assess Brazilian schoolchildren's dietary intake.

## Methods

### Description of the CADE app

CADE (*Consumo Alimentar no Domicílio e na Escola* [Food Consumption at Home and at School]) (Brazilian National Institute of Industrial Property, registration number: BR512021001151-1) is an app for mobile data collection devices (MDCD), i.e. smartphones and tablets, available on the Android platform for downloading via the Play Store, with online functionality, allowing research to assess the diet of Brazilian schoolchildren 4–9 years of age.

The CADE technology assesses the child's entire dietary intake, since it allows estimating food consumption in all dietary environments in which children eat, mainly at home and school. The app also has an option for recording previously collected dietary data.

### Development of the CADE app

**Selection of food database, household measurements and photos of food portions.** The CADE database consisted of food items ranging from simple foods and beverages to complex recipes from the 2017–18 Brazilian National Dietary Survey (INA – a national survey that assessed food consumption through two 24-HR in a probabilistic sample of individuals 10 years and older)<sup>(45)</sup>; the 2019 National Survey on Child Nutrition (ENANI – a nationwide survey that assessed diet through one 24-HR in a probabilistic sample of children under 5 years of age)<sup>(40)</sup>; menus offered in public schools across the country prepared by the technical team of the National School Feeding Program (PNAE); and the food and beverage databases of Brazilian regional surveys that assessed schoolchildren's dietary intake<sup>(46–50)</sup>.

Household measurements were used to quantify dietary intake, specific for each food item. The measurements were mostly extracted from the 2017–18 INA database<sup>(45)</sup> and complemented by digital photos of measurements used specifically for children in the ENANI database<sup>(40)</sup>. Official authorisation was obtained to use digital photos of children's household measurements and food portions available in the Brazilian Manual of Child Food Portion Quantification, developed specifically for the ENANI survey<sup>(51)</sup>.

**Functionalities.** The dietary assessment method and the app's technological tools were chosen based on a literature review of existing tools<sup>(15,25,27,40,52)</sup> and created with the collaboration of two software developers as detailed below.

The app allows two types of access: (1) by the administrator, who accesses a platform that allows the creation of user accounts by the definition of login and password. The administrator provides the user's access through a login and password. They are also responsible for performing a simple registration of the child, generating three 6-digit numeric codes in which the sixth and last digit are specific to the interface that the user completes on the child's dietary data (home, school or previously collected data) and (2) by users, who record the children's dietary data.



The dietary assessment method was chosen specifically for each food environment, namely school and home, the latter including all food consumed inside and outside the home except foods consumed at school. The 6-digit numeric code allows merging data from both environments, aggregating dietary data from the same day of the child's food consumption. The child's dietary report at school is initiated by an adult aware of the child's dietary intake inside school (e.g. teacher, school staff or field researcher) using a food record (FR). On the day following the school dietary intake report, the child's dietary intake at home is recorded by parents or guardians through a 24-HR. The app also allows recording the child's dietary data that have been collected previously on paper or another medium, allowing the automation and standardisation of dietary data. Fig. 1 displays a flowchart showing the stages of dietary assessment in the app's three interfaces.

Regardless of the type of food environment, when users open the app, they must enter their login and password, previously provided by the administrator. After entering the app, they begin the report by providing the child's numerical code in a specific environment for which they are reporting the dietary intake. The child socio-demographic data including name, sex, age and place of birth are requested after accessing the child's code.

In the home environment, respondents complete the child's demographic data and answer five questions related to dietary habits: whether the reported dietary intake refers to an unusual day (with six options: holidays, travel, vacations, illness, fasting [including religious] or 'no'); whether the child is on a special diet (ten options: lacto-ovo vegetarian, vegetarian/vegan, lactose-intolerant, egg-, milk- or gluten-allergy, phenylketonuria, diabetes, religious diet or 'no'); what the child (or the child's parent or guardian) uses to sweeten foods or beverages consumed by the child (four options: only sugar, only sweetener, both sugar and sweetener or neither); whether the child (or the child's parent or guardian) adds salt to the child's meals (yes or no); and the frequency of seven dietary supplements (calcium, iron, multivitamins, vitamin C, vitamin D, vitamin B and omega-3/fish oil). The questions were based on the 2017–18 INA survey<sup>(45)</sup>, adapted to schoolchildren's dietary habits.

After these questions, the app proceeds to the 24-HR, applying the multiple-pass method<sup>(53)</sup>: (1) Quick list: entry of all foods and beverages consumed by the child on the previous day. Filters were created to facilitate searching foods that appear with their names repeatedly in the database, for example 'rice'. The app also allows the inclusion of new food items that are not in the app's food database. (2) Probing questions: respondents answer questions on overlooked food items such as candy, beverages or sweets. However, these questions are answered by the children themselves when they are 8 years or older. (3) Details of food items: ways of preparing food; questions on extra food ingredients added to the reported foods (such as ketchup on hamburger); type of household measurements used to serve food or standard food units consumed. The latter was used to quantify dietary intake and included digital photos of household measurements (such as cups, spoons and bowls) and standard food portions usually consumed by children<sup>(51)</sup>. (4) Time and

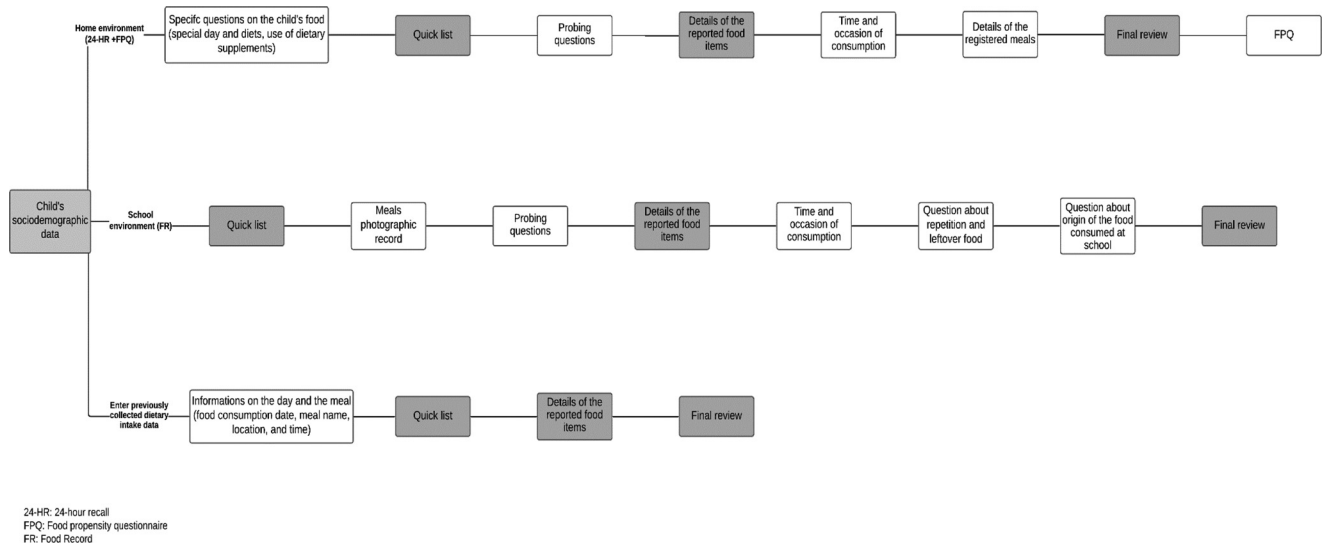
occasion of consumption: for each food item reported, the respondent must inform the name and time of the meal. (5) Details on the recorded meals: the respondent informs the place where the child ate the meal, indicating whether the child was engaged in any other activity while eating. (6) Final review: the respondent answers two questions to verify overlooked food items and double-checks all food items already reported, which are: whether child drank something between meals, considering any drink (including water), and whether he or she ate anything between meals, considering any food, even in small amounts, such as candy, cookies and snacks. (7) Food Propensity Questionnaire (FPQ): the respondent completes a food propensity questionnaire (FPQ) to inform the frequency of the child's consumption of food items in the previous month (Fig. 1), with five frequency options ranging from 'never' to '6–7 days a week'. The FPQ consisted of 38 food items distributed into seven food groups organised by their similarity and importance in the diet quality, such as grains, fruits, sausages and seafood.

In the school environment, the respondent accesses the app every time the child is eating a meal, to report the child's food intake through an FR. Dietary assessment follows the same steps that the respondent performs in the home environment: quick list, probing questions, details of food items, time and occasion of consumption and final review. However, an additional step after completing the quick food list allows the respondent to take a photo of the child's meal or food intake. The respondent can also inform whether the child had 'seconds' of the food (i.e. repeated the portion) or if there was any leftover meal or food on the plate. The food's origin can be recorded (whether food comes from school lunches, whether food was brought from home or bought at the school canteen). Another specific feature of the school environment is that the respondent can activate notifications from the app at the end of each child's meal report. This activation sends messages on the user's cellphone or tablet every 2 h, so that they do not forget to access it to report meals that the child eats at school.

The respondent can also use the app to enter previously collected dietary intake data. Some steps completed in the dietary data are the same as those used to assess dietary intake at school, except for the use of technological tools such as photos of the meal, digital photos that assist quantification, questions on extra food ingredients added to reported foods, and other activities performed while eating (Fig. 1).

### *Managing files in the app*

The app allows exporting two files related to data obtained in the school and home environments and a third file related to previously collected data. The tool's data files (.csv extension) are: (1) child's socio-demographic data from the home and school environments, such as age, gender, grade and school shift; (2) dietary intake at home and school; and (3) dietary intake from previously collected data. This latter file is only generated when dietary data are not collected directly at school or home. The exported files for the school and home



**Fig. 1.** Flowchart of steps for use of the CADE app in the school and home environments and for entering previously collected dietary data.

environments can be 'linked' by the child's code, allowing analysis of the child's dietary intake on the same day.

### Data analysis

A descriptive analysis by absolute and relative frequencies was performed for characterisation of the app's database and description of its functionalities using the R Studio software, version 4.0.3.

### Ethical issues

The research project was approved by the Institutional Review Board of the Sergio Arouca National School of Public Health – ENSP/FIOCRUZ (CAAE 58831516.0.0000.5240).

### Results

The unique questions in the home environment of the CADE app concern the performance of activities during meals, with five options: use of smartphone or tablet, videogames, watching TV, use of computer or laptop and none of the above, and a FPQ consisting of thirty-eight food items distributed in seven food groups organised in blocks according to their similarity and importance in the quality of the diet, such as grains, fruit, vegetables, sausage, seafood, salty snacks, and cakes and cookies, with five options for frequency of consumption, varying from never or less than once a month to 6 or 7 days a week.

Four unique questions or features were included in the school environment: possibility of photographing the child's meals; report of leftover food with four semi-quantitative options: 'half the meal left over', '1/3 left over', 'almost everything left over' and 'almost nothing left over'; report and quantification of repetition of food items ('seconds'); and receipt of notification to access the app to record a new meal. The remaining questions are similar in both the home and school environments.

The app features a sequence of four probing questions to detect possible overlooked foods. An interesting feature is that the app recognises the child's age at which the parent/guardian is reporting dietary intake. If the child is 8 years or older, these probing questions are addressed to the child. As already shown in international studies<sup>(14,16,54)</sup>, from 8 years of age onwards, children are expected to have more autonomy in their food choices and to recognise food intake and assist the parents' report.

The CADE app's database contains 2125 food items, of which approximately 84 % were foods in the INA survey 2017–18<sup>(45)</sup>, 11 % from the database contained in the ENANI mobile app<sup>(40)</sup>, 5 % from the menus of the National School Meals Program and less than 1 % from the databases of Brazilian regional surveys. The list includes foods commonly consumed by the Brazilian population, with an emphasis on Brazilian schoolchildren's eating habits, including regional foods.

More than half of the food items list represents simple foods, such as meats, fruits and vegetables, while approximately 37 % of the database included more complex recipes such as cakes, pies and feijoada (a traditional Brazilian pork-and-beans dish). A total of nine types of food preparations such as raw, roasted and cooked with fat were available. Among the eighteen options of additional ingredients, the respondent can choose among items to sweeten food or beverages (like sugar, honey, molasses), sauces (ketchup, mustard, mayonnaise), and ingredients used by children in combination with other foods, such as granola and oatmeal. This functionality for selecting additional items is qualitative. The options for selecting the type of preparations and additional ingredients vary according to the reported food item, and not all foods allow selection of the type of preparation and additional items. Approximately 38 and 18 % of simple foods allow selection of additional ingredients and type of preparation, respectively (Fig. 2).

The quantification forms were specific to the food item and consisted of 75 household measurements (e.g. mug, glass,



bowl, ladle, plate) and 466 digital images, 440 of which are digital images of 296 food portions, to facilitate reporting the amounts consumed and to minimise measurement errors with the app<sup>(55,56)</sup>. The size of these food portions was based on children's usual dietary intake<sup>(51)</sup>. A total of twenty-six digital images of four types of household items were also available, mostly used specifically by children, such as children's spoons and bowls and measures of infant formulas or supplements (Fig. 2). Such digital photos of household measurements allow estimating quantities such as  $\frac{1}{2}$ ,  $\frac{1}{3}$ ,  $1 + \frac{1}{2}$ , allowing more accurate quantification (Supplementary Fig. S1).

During the detailed recording of meals in the home environment and in the interface for entering previously collected dietary data, the app provides eight predefined meal options, namely breakfast, brunch, lunch, afternoon snack, dinner, supper, evening snack and late-night snack, and eight options for consumption places, such as home, home delivery, restaurant/snack bar (self-service/pay-by-weight/all-you-can-eat), restaurant (other type), recreational/social places (church, cinema, party venue), other people's homes (grandmother, friend, etc.) and on the street (food purchased from street vendors). However, details of meals in the school environment consist solely of identifying the origin of the food consumed at school, such as school lunches, food consumed in the cafeteria or food brought from home.

The final stage of the report is a review of food items and meals, plus two final questions on overlooked food items. Once the dietary intake is recorded in both environments (home and school), the app allows exporting the two files referring to the child's socio-demographic data and dietary intake at school and home.

A user's manual was developed for the app<sup>(57)</sup>, along with informational and demo videos for each food environment<sup>(58)</sup>.

## Discussion

The CADE app was based on mobile devices developed to collect dietary data from Brazilian schoolchildren using the FR and multiple-pass 24-hour recall combined with a FPQ, as well as allowing the entry of previously collected dietary data. The app was designed to standardise, automate and minimise costs and errors in the assessment of schoolchildren's dietary intake. The CADE app evaluates the school meals and integrate them with food intake at home. Moreover, the app allows to select food and household measurement digital photos to capture more accurately the amount consumed. We believed that underreporting can be minimised with this design, considering the resources that facilitate the amount consumed report and complete child's diet evaluation by investigating different consumption places<sup>(59)</sup>. Some new technological features compared to usual Brazilian technologies<sup>(28,29,40-44)</sup>, such as taking digital photos of food or meals and sending notifications in real time are only possible using online mobile devices.

The option to develop a self-report tool was mainly to make data collection feasible in two different environments, school and home. In addition, food record, the dietary assessment method in the school environment, is usually applied in self-report format. An international study showed that, compared

to interview-based 24-HR, 70 % of 1081 North American adults preferred self-reported 24-HR using ASA24 (Automated Self-Administered 24-h Recall), in all demographic groups consulted<sup>(33)</sup>.

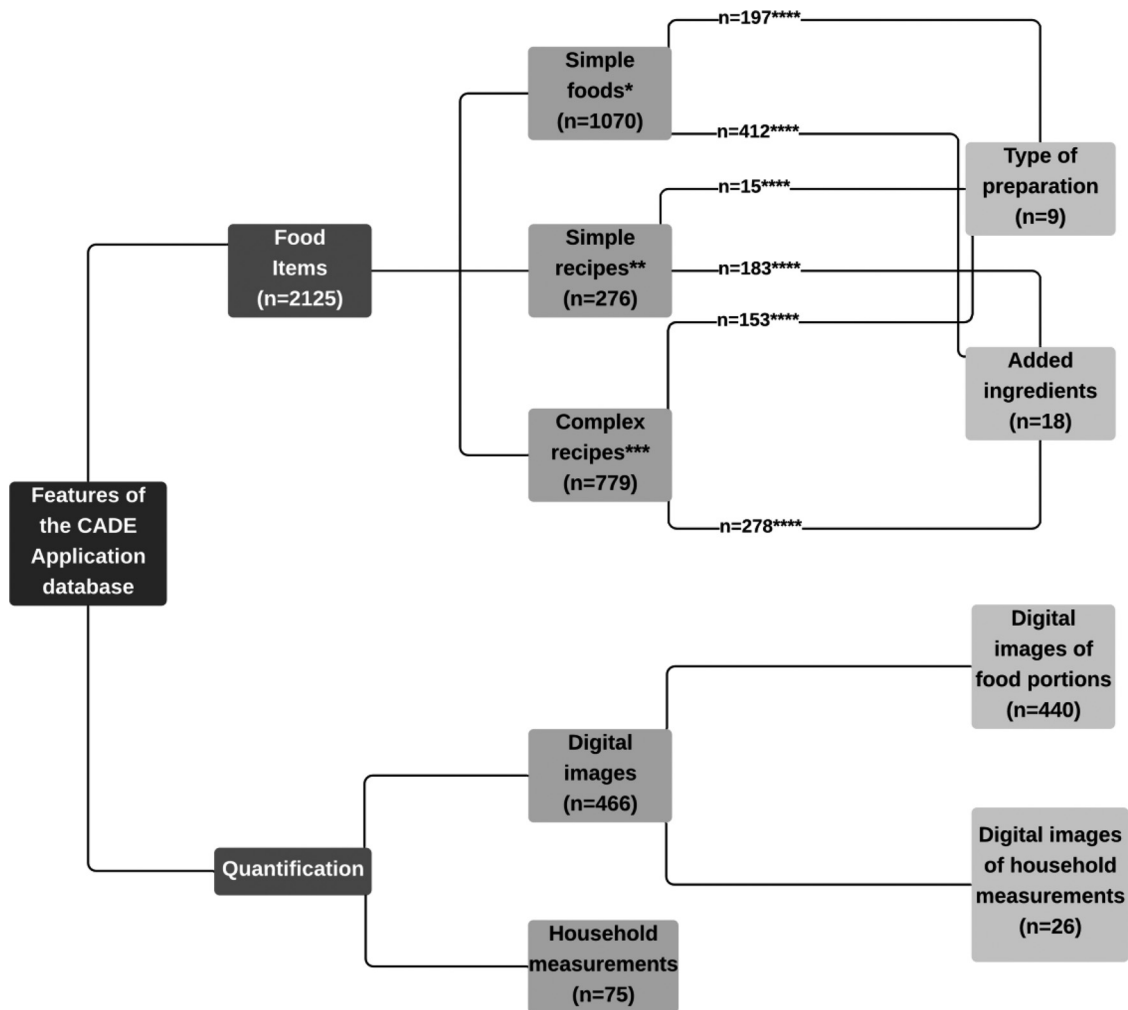
Regarding the methodological resources, we opted for the 24-HR applied with the multiple-pass method accompanied by a FPQ in the home environment and the FR in the school environment, both reported by an adult answering for the child in their respective places. 24-HR administered through multiple pass is internationally recognised as the best method for dietary assessment in different age groups<sup>(27,60,61)</sup>. The combination of 24-HR and FPQ has been recommended to improve the estimate of the usual intake of episodic food<sup>(62-64)</sup>. Some studies have already reported good results with the use of a FPQ for dietary assessment of children<sup>(65,66)</sup>.

Meanwhile, the choice of FR in the school was based on two main issues: the need to combine the dietary data from school with the same day as those from the home environment and the assumption that whoever answers for the child's diet at school may be responsible for feeding many other children, and thus, the recall bias would be minimised by reporting child's diet in real time. In addition, FR has been proposed as the most suitable methodology for assessing young children's dietary intake<sup>(47)</sup>. Results from the EFCOVAL-child project showed that the FR applied for two non-consecutive days with the aid of a photographic manual for food quantification was the best method for children 4-6 years of age<sup>(13)</sup>.

The choice of the 24-HR and FR also assumed that quantitative dietary assessment is essential in this age group. Energy and nutrient intake, prevalence of inadequate nutrient intake, food pattern analysis and adequacy of diets are some examples that depend on quantitative data<sup>(67,68)</sup>.

The CADE database was developed to be comparable to databases from the Brazilian national surveys<sup>(45,69)</sup>. However, few technologies have been developed specifically for the Brazilian population, and even fewer use databases based on nationwide dietary intake<sup>(40,41,44)</sup>. The development of Brazilian technologies to assess dietary intake is incipient and recent in the country. In addition, technological advances already developed internationally such as automated recognition and quantification of foods in digital photos, the use of cameras and sensors in dietary assessment, and the use of food product barcodes in data collection has still not been described in any Brazilian technologies<sup>(21,23,70)</sup>.

Quantitative estimates of dietary intake have been recognised as a major source of error in self-reported dietary assessment methods<sup>(53)</sup>. Photographs of food portions have been identified to improve the estimation of portion sizes<sup>(55)</sup>; therefore, some automated 24-HR have integrated digital photo viewing into their platforms<sup>(22,71-75)</sup>. A recent Brazilian study using 24-HR from GloboDiet software found that digital and print photographs provided greater flexibility in interviewing individuals with less education, besides facilitating the quantification stage during the report. According to the authors, all respondents stated that it was 'easy' to quantify foods using photographs<sup>(55)</sup>. In another study with the same data stated above, the authors showed that individuals were able to properly recognise food portion sizes using print and



\* Foods such as meats, milk, fruits and vegetables

\*\* Recipes such as cooked rice, baked beans, bread with margarine, bread with jelly

\*\*\* Recipes such as cakes, pies and feijoada (brazilian black bean stew brewed with a variety of salted and smoked pork and beef products)

\*\*\*\* Not all foods allow the selection of preparation options (such as raw, grilled) and addition items (such as sugar, sauces) in the CADE application, thus we showing the information on how many foods allow the selection of types of preparation and addition items.

**Fig. 2.** Main features of the CADE app database.

digital photos available on a tablet. However, the authors found that among individuals with low schooling, digital photos in tablets were more subject to underestimation than print photos<sup>(56)</sup>.

In the CADE app, users in the school environment can take photos of the food or dish. Although the app lacks technology for automatic recognition and quantification of the photographed food, we believe that the photo may be useful in the short term, helping to manually recognise any food item that may have been overlooked in the report. Besides, in the long term, it can help produce an image database that can be used in technological innovations employing artificial intelligence and allowing the image-assisted recognition and measurement of food<sup>(56,74–76)</sup>.

The technology-based assessment of dietary intake has become increasingly relevant, even essential, acknowledging the need to optimise traditional dietary assessment instruments, standardise the data collection, obtain more accurate and reliable

data, develop more innovative and less expensive survey alternatives, and enhance the interviewee's attention and motivation, thereby increasing the response rate<sup>(76)</sup>. From this perspective, technologies applied to smartphones seem attractive, since the use of these mobile devices has become increasingly popular. International studies have reported good results with the use of smartphones to assess dietary intake, demonstrating that they can be intuitive, practical and modern, thus serving as the technology of choice for participants<sup>(77,78)</sup>.

In 2018, 99.2 % of Brazilian households used the internet, with cellphones as the most widely used technological tool for this purpose, with little difference between urban and rural areas<sup>(79)</sup>. Despite access to the internet and the widespread use of cellphones in Brazil, individuals from lower socioeconomic strata experience limitations in the use of internet and mobile devices<sup>(80,81)</sup>, and even individuals from higher socioeconomic strata may display digital illiteracy in the use of these tools<sup>(79,82)</sup>. However, an international study has found



that even in low-income countries, the electronic collection of dietary data can be a feasible alternative<sup>(36,83)</sup>.

The app presents some limitations, such as the recipe list in the database. The list in the app is closed, not allowing modification of recipe ingredients. This issue can be minimised with the possibility of inserting new foods and/or recipes. It is worth mentioning that only one Brazilian technological tool is capable of editing recipes: the Brazilian version of GloboDiet, which consists of an offline software that assesses food consumption through an interview-based 24-HR<sup>(44)</sup>. However, GloboDiet was developed for adults and is still not freely accessible. Another limitation is that the app does not integrate information on the nutritional composition and weight of the amount consumed in an automated way, which would allow it to generate instant feedback on individuals' energy and nutrient intakes.

In addition, the app has still not been tested initially for its usability and later for its validity in dietary assessment. These evaluations will help identify the average time spent to record the dietary data, the functionalities that need to be reviewed and improved, the data quality, and the tool's applicability to specific population groups such as individuals with less schooling.

Regarding the strengths of the present study, the CADE app is the first Brazilian technological tool to assess schoolchildren's qualitative and quantitative dietary data. As it is a technology-based on mobile collection device, it may promote accessibility, ease of data collection, and cost reduction for scientific research. The tool features improve episodically food intake estimates by combining the 24-HR and FPQ methods, enhance the reporting amount consumed by integrating digital photos of food portions and household measurements, and the manual recognition of forgotten food items by photographing children's meals in the school environment.

Efforts are needed to make this technological tool available to large-scale studies: testing the app usability to improve the design, flow and content of the application based on users feedback, and testing the app usability specifically among less educated Brazilian children. After the usability tests, we intended to evaluate the validity of the app dietary information compared to other food assessment methods and biomarkers. After these steps, we believe that the CADE app can assist the standardisation and automation of schoolchildren's dietary data collection, promoting the development of studies in nutritional epidemiology and nutrition and public health, as well as in primary healthcare for children.

## Conclusion

The app design included complex flows that integrate the food consumption assessment in school and home environments and allow entering previously collected food data. Its features are innovative, such as viewing digital photos of household measurements and food portions to estimate the amount consumed and receive notifications to remind the user to report the children's food intake. Thus, providing a technological tool to assess Brazilian school children's food consumption can reduce biases, costs and time.

## Supplementary material

The supplementary material for this article can be found at <https://doi.org/10.1017/jns.2022.25>.

## Acknowledgements

This work was supported by Coordination for the Improvement of Higher Education Personnel (CAPES) (financing code 001), Sergio Arouca National School of Public Health/Oswaldo Cruz Foundation (Fiocruz) (ENSP process: 25388-000497/2017-46), National Counsel of Technological and Scientific Development (CNPq) (process: 409933/2018-0) and State Research Support Foundation of State Rio de Janeiro (FAPERJ) (process: 201.960/2018).

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. There are no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained. This work was reported according to the Strengthening the Reporting of Observational Studies guidelines for nutritional epidemiological studies (STROBE-nut).

J. V. F. and M. C. A. contributed to research conception and managed the study planning. S. P. C. contributed to drafting and critical review of the article. All authors reviewed and commented on subsequent drafts of the manuscript and approved the final manuscript. This study was approved by the National Research Ethics Commission (under CAAE 58831516.0.0000.5240).

The authors have no conflict of interests.

## References

1. Afshin A, Sur PJ, Fay KA, *et al.* (2019) Health effects of dietary risks in 195 countries, 1990–2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet* **393**, 1958–1972.
2. Craigie AM, Lake AA, Kelly SA, *et al.* (2011) Tracking of obesity-related behaviours from childhood to adulthood: a systematic review. *Maturitas* **70**, 266–284.
3. Cavalcante AA, Tinôco AL, Cotta RM, *et al.* (2006) Food consumption and nutritional profile of children seen in public health services of Viçosa, Minas Gerais, Brazil. *Rev Nutr* **19**, 321–330.
4. Carvalho CAD, Fonsêca PCDA, Priore SE, *et al.* (2015) Consumo alimentar e adequação nutricional em crianças brasileiras: revisão sistemática. *Rev Paul Pediatr* **33**, 211–221.
5. Collins CE, Watson J & Burrows T (2010) Measuring dietary intake in children and adolescents in the context of overweight and obesity. *Int J Obes (Lond)* **34**, 1103–1115.
6. Livingstone MBE, Robson PJ & Wallace JMW (2004) Issues in dietary intake assessment of children and adolescents. *Br J Nutr* **92**, S213–S222.
7. Foster E & Adamson A (2014) Challenges involved in measuring intake in early life: focus on methods. *Proc Nutr Soc* **73**, 201–209.
8. Livingstone MBE & Black AE (2003) Markers of the validity of reported energy intake. *J Nutr* **133**, 895S–920S.
9. Slimani N, Freisling H, Illner AK, *et al.* (2015) Methods to determine dietary intake. In *Nutrition Research Methodologies*, pp. 48–78 [J Lovegrove, L Hodson, S Sharma and S Lanham-New, eds]. Chichester, West Sussex, UK: John Wiley & Sons Ltd.
10. Burrows TL, Martin RJ & Collins CE (2010) A systematic review of the validity of dietary assessment methods in children when compared with the method of doubly labeled water. *J Am Diet Assoc* **110**, 1501–1510.

11. Subar AF, Kipnis V, Troiano RP, *et al.* (2003) Using intake biomarkers to evaluate the extent of dietary misreporting in a large sample of adults: the OPEN study. *Am J Epidemiol* **158**, 1–13.
12. European Food Safety Authority. (2014) Guidance on the EU menu methodology. *EFSA J* **12**, 3944.
13. Trolle E, Amiano P, Ege M, *et al.* (2011) Feasibility of 2× 24-h dietary recalls combined with a food-recording booklet, using EPIC-soft, among schoolchildren. *Eur J Clin Nutr* **65**, S65–S76.
14. Diep CS, Hingle M, Chen TA, *et al.* (2015) The automated self-administered 24-hour dietary recall for children, 2012 version, for youth aged 9 to 11 years: a validation study. *J Acad Nutr Diet* **115**, 1591–1598.
15. Freisling H, Ocké MC, Casagrande C, *et al.* (2015) Comparison of two food record-based dietary assessment methods for a pan-European food consumption survey among infants, toddlers, and children using data quality indicators. *Eur J Nutr* **54**, 437–445.
16. Medin AC, Astrup H, Kåsin BM, *et al.* (2015) Evaluation of a web-based food record for children using direct unobtrusive lunch observations: a validation study. *J Med Internet Res* **17**, e273.
17. Arens-Volland AG, Spassova L & Bohn T (2015) Promising approaches of computer-supported dietary assessment and management—current research status and available applications. *Int J Med Inform* **84**, 997–1008.
18. Style S, Beard BJ, Harris-Fry H, *et al.* (2017) Experiences in running a complex electronic data capture system using mobile phones in a large-scale population trial in southern Nepal. *Glob Health Action* **10**, 1330858.
19. Tomlinson M, Solomon W, Singh Y, *et al.* (2009) The use of mobile phones as a data collection tool: a report from a household survey in South Africa. *BMC Med Inform Decis Mak* **9**, 1–8.
20. Thompson FE, Subar AF, Loria CM, *et al.* (2010) Need for technological innovation in dietary assessment. *J Acad Nutr Diet* **110**, 48–51.
21. Eldridge AL, Piernas C, Illner AK, *et al.* (2019) Evaluation of new technology-based tools for dietary intake assessment—an ILSI Europe dietary intake and exposure task force evaluation. *Nutrients* **11**, 55.
22. Bradley J, Simpson E, Poliakov I, *et al.* (2016) Comparison of INTAKE24 (an online 24-h dietary recall tool) with interviewer-led 24-h recall in 11–24 year-old. *Nutrients* **8**, 358.
23. Kouvari M, Mamalaki E, Bathrellou E, *et al.* (2020) The validity of technology-based dietary assessment methods in childhood and adolescence: a systematic review. *Crit Rev Food Sci Nutr* **61**, 1065–1080.
24. Timon CM, Van den Barg R, Blain R, *et al.* (2016) A review of the design and validation of web- and computer-based 24-h dietary recall tools. *Nutr Res Rev* **29**, 268–280.
25. Moore HJ, Hillier FC, Batterham AM, *et al.* (2014) Technology-based dietary assessment: development of the Synchronised Nutrition and Activity Program (SNAPT<sup>TM</sup>). *J Hum Nutr Diet* **27**, 36–42.
26. Delisle C, Sandin S, Forsum E, *et al.* (2015) A web- and mobile phone-based intervention to prevent obesity in 4-year-olds (MINISTOP): a population-based randomized controlled trial. *BMC Public Health* **15**, 1–8.
27. Carvalho MA, Baranowski T, Foster E, *et al.* (2015) Validation of the Portuguese self-administered computerised 24-hour dietary recall among second-, third- and fourth-grade children. *J Hum Nutr Diet* **28**, 666–674.
28. Davies VF, Kupek E, Assis MA, *et al.* (2015) Validation of a web-based questionnaire to assess the dietary intake of Brazilian children aged 7–10 years. *J Hum Nutr Diet* **28**, 93–102.
29. Kupek E & de Assis MAA (2016) The use of multiple imputation method for the validation of 24-h food recalls by part-time observation of dietary intake in school. *Br J Nutr* **116**, 904–912.
30. Biloft-Jensen AP (2012) *Web-based dietary assessment for 8–11 year old school-children*. PhD Thesis, National Food Institute.
31. Andersen R, Biloft-Jensen A, Christensen T, *et al.* (2015) What do Danish children eat, and does the diet meet the recommendations? Baseline data from the OPUS School Meal Study. *J Nutr Sci* **4**, e29.
32. Baranowski T, Islam N, Baranowski J, *et al.* (2012) Comparison of a web-based versus traditional diet recall among children. *J Acad Nutr Diet* **112**, 527–532.
33. Thompson FE, Dixit-Joshi S, Potischman N, *et al.* (2015) Comparison of interviewer-administered and automated self-administered 24-hour dietary recalls in 3 diverse integrated health systems. *Am J Epidemiol* **181**, 970–978.
34. Medin AC, Carlsen MH & Andersen LF (2016) Associations between reported intakes of carotenoid-rich foods and concentrations of carotenoids in plasma: a validation study of a web-based food recall for children and adolescents. *Public Health Nutr* **19**, 3265–3275.
35. Jung HJ, Lee SE, Kim D, *et al.* (2015) Improvement in the technological feasibility of a web-based dietary survey system in local settings. *Asia Pac J Clin Nutr* **24**, 308–315.
36. Caswell BL, Talegawkar SA, Dyer B, *et al.* (2015) Assessing child nutrient intakes using a tablet-based 24-hour recall tool in rural Zambia. *Food Nutr Bull* **36**, 467–480.
37. Baranowski T, Islam N, Douglass D, *et al.* (2014) Food Intake Recording Software System, version 4 (FIRSt4): a self-completed 24-h dietary recall for children. *J Hum Nutr Diet* **27**, 66–71.
38. Nicklas T, Islam NG, Saab R, *et al.* (2018) Validity of a digital diet estimation method for use with preschool children. *J Acad Nutr Diet* **118**, 252–260.
39. Ahmad Z, Bosch M, Khanna N, *et al.* (2016) A mobile food record for integrated dietary assessment. In *Proceedings of the 2nd International Workshop on Multimedia Assisted Dietary Management*, pp. 53–62.
40. Lacerda EMA, Boccolini CS, Alves-Santos NH, *et al.* (2021) Methodological aspects of the assessment of dietary intake in the Brazilian National Survey on Child Nutrition (ENANI-2019): a population-based household survey. *Cad Saude Pública* **37**, e00301420.
41. Barufaldi LA, Abreu GDA, Veiga GVD, *et al.* (2016) Programa para registro de recordatório alimentar de 24 horas: aplicação no Estudo de Riscos Cardiovasculares em Adolescentes. *Rev Bras Epidemiol* **19**, 464–468.
42. Lima NMDS, Leal VS, Oliveira JS, *et al.* (2021) Excess weight in adolescents and associated factors: data from the ERICA study. *J Pediatr* **97**, 676–684.
43. Bricarello LP, de Almeida Alves M, Retondario A, *et al.* (2021) DASH diet (Dietary Approaches to Stop Hypertension) and overweight/obesity in adolescents: the ERICA study. *Clin Nutr ESPEN* **42**, 173–179.
44. Steluti J, Crispim SP, Araujo MC, *et al.* (2020) Tecnologia em Saúde: versão brasileira do software GloboDiet para avaliação do consumo alimentar em estudos epidemiológicos. *Rev Bras Epidemiol* **23**, e200013.
45. Instituto Brasileiro de Geografia e Estatística (2020) *Pesquisa de Orçamentos Familiares 2017–2018. Análise do consumo alimentar pessoal no Brasil*. Rio de Janeiro: IBGE.
46. Silva JVL, Timóteo AKCD, Santos CDD, *et al.* (2010) Consumo alimentar de crianças e adolescentes residentes em uma área de invasão em Maceió, Alagoas, Brasil. *Rev Bras Epidemiol* **13**, 83–93.
47. Costa FFD (2013) *Desenvolvimento e avaliação de um questionário baseado na web para avaliar o consumo alimentar e a atividade física de escolares*. PhD Thesis, Universidade Federal de Santa Catarina.
48. Sparrenberger K, Friedrich RR, Schiffner MD, *et al.* (2015) Consumo de alimentos ultraprocesados entre crianças de uma Unidade Básica de Saúde. *J Pediatr (Rio J)* **91**, 535–542.
49. Fortins RF, Lacerda EM, Silverio RNC, *et al.* (2019) Predictor factors of glycemic control in children and adolescents with type 1 diabetes mellitus treated at a referral service in Rio de Janeiro, Brazil. *Diabetes Res Clin Pract* **154**, 138–145.
50. Conceição SIO, Santos CDJND, Silva AAM, *et al.* (2010) Consumo alimentar de escolares das redes pública e privada de ensino em São Luís, Maranhão. *Rev Nutr* **23**, 993–1004.





51. Crispim SP, Mauricio A, Almeida CCB, *et al.* (2018) *Manual Fotográfico de Quantificação Alimentar Infantil*, 1st ed., p. 159. Curitiba: Universidade Federal do Paraná.
52. Biltoft-Jensen A, Bysted A, Trolle E, *et al.* (2013) Evaluation of Web-based Dietary Assessment Software for Children: comparing reported fruit, juice and vegetable intakes with plasma carotenoid concentration and school lunch observations. *Br J Nutr* **110**, 186–195.
53. Marchioni DML, Gorgulho BM & Steluti J (2019) *Consumo Alimentar: Guia Para Avaliação*, 1st ed. Barueri: Manole.
54. Illner AK, Freisling H, Boeing H, *et al.* (2012) Review and evaluation of innovative technologies for measuring diet in nutritional epidemiology. *Int J Epidemiol* **41**, 1187–1203.
55. Koubik NA, Medeiros CO, da Silva GV, *et al.* (2020) Perspectives from individuals with low education and interviewers using the GloboDiet 24 h recall: a qualitative study. *J Nutr Sci* **9**, e13.
56. Nichelle PG, Almeida CC, Camey SA, *et al.* (2019) Subjects' perception in quantifying printed and digital photos of food portions. *Nutrients* **11**, 501.
57. Freitas JV (2021) *Desenvolvimento de um aplicativo móvel para avaliar a dieta de crianças escolares brasileiras entre 4 e 9 anos de idade*. Master's Thesis. Escola Nacional de Saúde Pública Sergio Arouca, Fundação Oswaldo Cruz.
58. CADE - Consumo Alimentar no Domicílio e na Escola (2021) *Vídeo demonstrativo do ambiente domiciliar-aplicativo CADE [video file]*. [cited 2021 Jun 21]. [https://www.youtube.com/watch?v=7U69oX\\_HUkY&t=1s](https://www.youtube.com/watch?v=7U69oX_HUkY&t=1s) (accessed June 2021).
59. Food and Agriculture Organization of the United Nations (2018) *Dietary Assessment: A Resource Guide to Method Selection and Application in Low Resource Settings*. Rome: FAO.
60. Bliss RM (2004) Researchers produce innovation in dietary recall. *Agric Res* **52**, 10–13.
61. Lafrenière J, Lamarche B, Laramée C, *et al.* (2017) Validation of a newly automated web-based 24-hour dietary recall using fully controlled feeding studies. *BMC Nutr* **3**, 1–10.
62. European Food Safety Authority (2009) General principles for the collection of national food consumption data in the view of a pan-European dietary survey. *EFSA J* **7**, 1435.
63. De Boer EJ, Slimani N, Van't Veer P, *et al.* (2011) The European food consumption validation project: conclusions and recommendations. *Eur J Clin Nutr* **65**, S102–S107.
64. Dodd KW, Guenther PM, Freedman LS, *et al.* (2006) Statistical methods for estimating usual intake of nutrients and foods: a review of the theory. *J Am Diet Assoc* **106**, 1640–1650.
65. Bel S & De Ridder K (2018) Belgian national food consumption survey in children. *EFSA Support Publ* **15**, 1467E.
66. Ocké M, Brants H, Dofkova M, *et al.* (2015) Feasibility of dietary assessment methods, other tools and procedures for a pan-European food consumption survey among infants, toddlers and children. *Eur J Nutr* **54**, 721–732.
67. Fisberg RM, Marchioni DML & Colucci ACA (2009) Avaliação do consumo alimentar e da ingestão de nutrientes na prática clínica. *Arq Bras Endocrinol Metabol* **53**, 617–624.
68. Assis AMO, Barreto ML, Santos MLP, *et al.* (2000) *Condições de vida, saúde e nutrição na infância em Salvador*. Salvador: Universidade Federal da Bahia, Instituto de Saúde Coletiva, Ministério da Saúde.
69. Instituto Brasileiro de Geografia e Estatística (2011) *Pesquisa de orçamentos familiares 2008-2009: análise do consumo alimentar pessoal no Brasil*. Rio de Janeiro: IBGE.
70. Amoutzopoulos B, Steer T, Roberts C, *et al.* (2018) Traditional methods v. new technologies—dilemmas for dietary assessment in large-scale nutrition surveys and studies: a report following an international panel discussion at the 9th International Conference on Diet and Activity Methods (ICDAM9), Brisbane, 3 September 2015. *J Nutr Sci* **7**, e11.
71. Carter MC, Albar SA, Morris MA, *et al.* (2015) Development of a UK online 24-h dietary assessment tool: myfood24. *Nutrients* **7**, 4016–4032.
72. Touvier M, Kesse-Guyot E, Méjean C, *et al.* (2011) Comparison between an interactive web-based self-administered 24 h dietary record and an interview by a dietitian for large-scale epidemiological studies. *Br J Nutr* **105**, 1055–1064.
73. Jacques S, Lemieux S, Lamarche B, *et al.* (2016) Development of a web-based 24-h dietary recall for a French-Canadian population. *Nutrients* **8**, 724.
74. Subar AF, Crafts J, Zimmerman TP, *et al.* (2010) Assessment of the accuracy of portion size reports using computer-based food photographs aids in the development of an automated self-administered 24-hour recall. *J Am Diet Assoc* **110**, 55–64.
75. Bel-Serrat S, Knaze V, Nicolas G, *et al.* (2017) Adapting the standardised computer- and interview-based 24 h dietary recall method (GloboDiet) for dietary monitoring in Latin America. *Public Health Nutr* **20**, 2847–2858.
76. Foster H, Walsh MC, Gibney MJ, *et al.* (2016) Personalised nutrition: the role of new dietary assessment methods. *Proc Nutr Soc* **75**, 96–105.
77. Bucher Della Torre S, Carrard I, Farina E *et al.* (2017) Development and evaluation of e-CA, an electronic mobile-based food record. *Nutrients*, **9**(1), 76.
78. Hutchesson MJ, Rollo ME, Callister R, *et al.* (2015) Self-monitoring of dietary intake by young women: online food records completed on computer or smartphone are as accurate as paper-based food records but more acceptable. *J Acad Nutr Diet* **115**, 87–94.
79. Instituto Brasileiro de Geografia e Estatística (2018) *Pesquisa Nacional por Amostra de Domicílios Contínua - Acesso à internet e à televisão e posse de telefone móvel celular para uso pessoal 2016 (PNAD TIC)*. Rio de Janeiro: IBGE.
80. Pinto NMA, Silva JKN & Fiúza ALC (2020) A posse e o uso das Tecnologias da Informação e Comunicação a partir da perspectiva de gênero e de geração. *Braz J Dev* **6**, 75822–75838.
81. Brasil. Presidência da República. Secretaria Especial de Comunicação Social (2016) *Pesquisa brasileira de mídia 2016: hábitos de consumo de mídia pela população brasileira*. Brasília: Secom.
82. Coelho AL, Moraes IA & Rosa WVS (2020) A utilização de tecnologias da informação em saúde para o enfrentamento da pandemia do COVID-19 no Brasil. *Cad Ibero Am Direito Sanit* **9**, 183–199.
83. Harris-Fry H, Beard BJ, Harrison T, *et al.* (2018) Smartphone tool to collect repeated 24 h dietary recall data in Nepal. *Public Health Nutr* **21**, 260–272.