Poor Validity of Dietary Recall in Low-Income Hispanic Children using Digital Food Imaging Analysis as the Reference

Trevino RP1*, Ravelo AV2, Senne-Duff B3, Murad M4, Diaz JP5 and Birkenfeld E6

1Social and Health Research Center, San Antonio, Texas, USA
2Promotion Llc, Miami, Florida, USA
3Department of Nutrition, University of the Incarnate Word, San Antonio, Texas, USA
4Data Management, Social and Health Research Center, San Antonio, Texas, USA

Received Date: March 11, 2016, Accepted Date: May 30, 2016, Published Date: June 8, 2016.
*Corresponding author: Roberto P Trevino, Social and Health Research Center, San Antonio, Texas, USA, 78210, Tel: 210-533-8886; Fax: 210-533-4107; E-mail: rtrevino@sahrc.org

Abstract

Background: The prevalence of obesity among all U.S. children continues to increase but among Hispanic children the increase is more pronounced. With childhood obesity and technology on the rise, conventional methods of assessing dietary intake through memory recall might need to be complemented with newer technologies.

Objective: To test the sensitivity and specificity of self-reported dietary recall using Digital Food Imaging Analysis as the reference.

Design: The study was observational where a cohort of students was followed prospectively for three consecutive days.

Participants: Third and fourth grade students ages eight to nine years from six elementary schools of two school districts (n = 213) of which most were Hispanic and economically disadvantaged.

Main outcome measures: Three day, 24 hour dietary recalls were collected during three consecutive days of meals they consumed the day before. On the same day of the analysis two stationary Internet Protocol cameras were taking images of pre- and post-meals. In this study only school breakfast and lunch meals were analyzed.

Statistical analyses performed: This study used a 2 × 2 contingency table to analyze the dietary recall for specificity, sensitivity, positive predictive value (PPV), and negative predictive value (NPV). Sensitivity = TP/(TP + FN), Specificity = TN/(TN + FP), PPV = TP/(TP + FP), and NPV = TN/(TN + FN) where TP = true positive, TN = true negative, FP = false positive, and FN = false negative. These then were tested for mean, standard deviation and 95% confidence.

Results: The sensitivity, specificity, PPV and NPV for the three days of dietary recall were 56%, 35%, 64%, and 27% respectively.

Conclusions: This study showed that self-reported dietary recalls were inaccurate assessing dietary intake in Hispanic children, ages eight to nine years, living in economically disadvantaged households. Methods using new technologies such as digital photography to complement memory recall should be explored.

Keywords: Validity; 24 Hour Dietary Recalls; Low-Income Hispanic children; Digital Photography

List of Abbreviations


Introduction

The prevalence of obesity, Body Mass Index (BMI) ≥ 95th percentile, among all U.S. children continues to increase but among Hispanic children the increase is more pronounced. The prevalence of obesity among Hispanic children age 6-11 years was 23.4% in 1999-2000; 20.1% in 2001-2002; and 22.5% in 2003-2004 [1]. During the same time periods and with the same age groups, the prevalence of obesity among non-Hispanic white children was 11.7%, 14.8% and 17.7%, respectively. A more recent study (2011-2012) showed that the prevalence of obesity among Hispanic and non-Hispanic white children the same age group was 26.1% and 13.1%, respectively [2]. Because of the relationship between unhealthy behaviors and obesity, better tools are needed to detect unhealthy behaviors and to measure correlations between these and obesity when changes occur. Given that dietary intake is a key component of intervention for childhood obesity prevention; studies are needed to assess the validity of self-reported dietary recalls in children most at-risk.

A systematic review of dietary intake instruments in children showed that self-reported dietary recalls provide good quality dietary intake as assessed by the standardized critical appraisal tool from the American Dietetic Association [3]. But Social and Health Research Center (SAHRC) investigators showed that this was not the case with low-income Hispanic children [4]. They conducted an evaluation of three day 24 hour dietary recalls and used an established prediction equation based on self-reported energy intake as a percentage of predicted energy requirement to identify under-, plausible-, and over-reporters. Only 39% of self-reported dietary recalls were assessed to be plausible-reporters.

Because the studies with positive results that were cited above did not include Hispanic children and to our knowledge there are no other validity studies of self-reported dietary recalls in low-income Hispanic children, the purpose of the present study was to evaluate this method in this particular population of children. The reference used to assess self-reported dietary recalls was Digital Food Imaging Analysis (DFIA; patent pending). Consuming insufficient amounts of minerals, consuming excessive amounts of calories, and being vitamin deficient are disorders. Like mental health, eating disorders, need to be diagnosed with valid instruments. We considered the self-reported dietary recalls as the diagnostic instrument and DFIA as the "gold standard" to measure specifically sensitivity and specificity. DFIA uses digital photography to identify food consumed. For this study only photographs of meals taken before and after being consumed were used as the reference to evaluate the validity of self-reported dietary recalls.

Materials and Methods

Participating Schools

The study was observational where a cohort of students was
followed prospectively for three consecutive days. Dietary data was collected from third and fourth grade children from six elementary schools of two school districts in San Antonio, TX. The participating school districts are urban, inner city, and 92 percent of the students enrolled were Hispanic and 89 percent participated in the National School Breakfast and School Lunch Programs (NSLP). All third and fourth grade students, regardless of race and ethnicity, were invited to participate. English and Spanish consent forms were either sent to parents by mail or carried by students in a folder schools used to inform parents of school activities. In addition, several dates were scheduled for face-to-face meetings with parents to explain the study and the consent forms. Only children who returned written informed consent forms signed by their parent/guardian and who assented to the study participated in data collection. The recruitment was conducted and data collected during the fall of 2012. The Institutional Review Board of the University of Texas Health Science Center at San Antonio approved the study protocol.

**Measures**

Student and school characteristics were collected from the school’s administrative offices, and from children and parents. These included age, gender, and race/ethnicity; English Language Learners (ELL), and NSLP eligibility; ELL is students who are unable to communicate fluently or learn effectively in English and NSLP eligibility was used as a proxy for economic disadvantage.

Three day, 24-hour dietary recalls were collected during three consecutive days according to the following schedule: Tuesday interview recorded what the child ate on Monday, Wednesday interview recorded what the child ate on Tuesday, and Thursday interview recorded what the child ate on Wednesday. The dietary intake data were all collected in the morning before breakfast on three different visits to the school so the child only had to recall one day’s food intake at a time. The dietary recalls were collected in either English or Spanish from children individually and face-to-face by 12 trained bilingual interviewers. The interviewers, undergraduate nutrition students, were trained by a registered diettian who had been certified through Nutrition Data System for Research. An extensive two day training and a third day of certification was required for all interviewers.

A multiple pass approach, modeled on the USDA method, was used to identify, describe, estimate serving size, and measure consumption of food [5]. Four passes were used. Identification - The first pass began with the interviewer prompting the participant using a script to recall food intake over the previous day. The interviewer wrote down each item with notations of times and meal types (breakfast, lunch, dinner and snack); Describe - The second pass was used to describe each food item listed in the first pass, particularly food preparation, branding, and cooking styles used; Serving size (food volume); - The third pass was used to ask the serving size or food portion size. In this phase, various types of visual aids and measuring devices (cups, spoons, ruler, and food models or pictures) were used to help guide the participants about the amounts of each food item served; and Consumption – The fourth pass was used to quantify the amount of food consumed.

We approached self-reported dietary recalls as diagnostic tools to detect nutrition-related disorders and used the Digital Food Imaging Analysis (DFIA) and school food service menus as the reference. The DFIA technology is being developed by SAHRC with a grant from the USDA (award no. 2011: 67001-30071). This technology uses digital photography, image-processing software, and the USDA National Nutrient Database for Standard Reference to identify food and nutritional value of food consumed. School food service menus were further used to confirm the food identified with the DFIA.

In addition to the undergraduate nutrition students stated above, there were two research assistants and one camera technician. The role of the research assistants was to observe students during meal times to document food brought from home and food exchanges that occurred during meals; the role of the technician was to snap photographs of bar codes and meals (before-after) and review the quality of the visual images before being streamlined to SAHRC. Consented children were given placards with bar codes that identified them. The placard was placed as a necklace and when the child went through the cameras they were instructed to place the placard under the camera so that the technician can snap photographs of the bar code and food that was served and food that was left over.

Two stationary Internet Protocol (IP) cameras (H.264) equipped with CCTV High-Definition lenses (Planet Technology, Taiwan) were placed in the six participating elementary school cafeterias. One set was positioned above the cash register to represent school meal servings and another set was placed above the disposal window to capture food waste. The cameras were assigned with a static IP address to send live streaming video via the internet to SAHRC for storage and image processing. Photographs of food and beverages, before and after meals, were taken on the same day of the data analysis. The school food service menus of meals served during the dates of dietary collection were obtained from school food service administrators to validate the foods shown in the photographs.

**Data Analysis**

Because of the controlled environment in schools, where research staff managed the operation of the DFIA technology and school food service administrators provided menus; and because of the unknown compliance of parents to follow the DFIA protocol at home - only school breakfast and lunch were used for this analysis.

Sensitivity, specificity, Positive Predictive Value (PPV), and Negative Predictive Value (NPV) were calculated as follows: Sensitivity = TP/(TP + FN), Specificity = TN/(TN + FP), PPV = TP/(TP + FP), and NPV = TN/(TN + FN); where TP = True Positive, TN = True Negative, FP = False Positive, and FN = False. TP was considered if the child reported consuming the food in the dietary recall and the food was observed in the before and not in the after photograph (reported and consumed); FP if the child reported consuming a food in the dietary recall but it was not observed in the before photograph or it was observed in the before and after photographs (reported but not consumed); TN if the child did not report consuming a food in the dietary recall and the food was not observed in the before photograph or observed in the before and after photographs (not reported and not consumed); and FN if the child reported not consuming a food in the dietary recall but it was observed in the before and not in the after photograph (an item observed to have been eaten but not reported). PPV is, for any particular positive test result, what is the probability that it is a TP; and NPV is, for any particular negative test result, what is the probability that it is a TN. In this paper intrusion and omission were used interchangeably with FP and FN, respectively. Table 1 depicts how sensitivity and specificity were assessed according to the self-reported dietary recall and the before and after photographs of meals.

The frequencies for all the categories were analyzed in a 2 × 2 contingency table. The 2 × 2 table provided the estimated values for prevalence, sensitivity, and specificity of the self-reported dietary recall method with its corresponding confidence interval. Moreover the estimated values for the probability of having a positive and negative answer were calculated; as well as the corresponding probability of TP and FP (intrusion) for the corresponding positive
answer and the probability for TN and FN (omission) for any negative answer.

The food items with higher counts for intrusion and omission were stratified by breakfast and lunch and ranked one through ten. The ranking of their frequency shows a visual understanding of which items are the best remembered and which are the most forgotten.

Results

Of a total of 1119 third and fourth grade students enrolled in the six elementary schools, 455 consented to participate in this study. Of these, 213 had complete dietary data. See Table 2 for participant characteristics. Children’s age was eight to nine years, most were Hispanic and economically disadvantaged and one fourth were ELL. When characteristics of participating students were compared to non-participating students, age, race/ethnicity, economic disadvantage and ELL were very similar except for gender (not shown). There were more girls (60%) in the participating group than in the non-participating (50%).

The meals in the photographs correlated 100% with those listed in school menus for each study day. The frequency values for TP and intrusions; and TN and omissions for each day were plotted in Figure 1. The graph shows that the higher frequencies were for omissions and TP and the lower frequencies for intrusions and TN values. These results reflect that children have a tendency to not report food that they consumed.

Table 3 shows the frequencies of TP, FP, TN, and FN for each day. Sensitivity, specificity, PPV and NPV for each of the three days are shown in Table 4. The results are almost identical for the three days and the confidence interval is small, which indicates a high precision of the analysis.

Because the self-reported dietary recalls were collected for three days, we calculated the aggregate mean and standard deviations for sensitivity and specificity (see Table 5). The results show small standard deviation values which reflect that sensitivity, specificity, TP, TN, omissions and intrusions and the likelihood ratios are very close to the mean value and the mean values were close to the values obtained each day. The positive and negative likelihood ratios of 0.85 and 1.3, respectively, were small and question the utility of self-reported dietary recalls in low-income Hispanic children.

There was an interest to determine if there were certain foods items that children reported as intrusions or omissions. Other than beverages commonly being falsely reported for breakfast, there were no specific patterns in their reporting.

Discussion

The results of this study show the poor validity of self-reported dietary recalls in low-income school-aged Hispanic children. The sensitivity, specificity, positive predictive value and negative predictive value for the three days of dietary recall were 56%, 35%, 64%, and 27% respectively. The sensitivity of 56% means that only 56% of what the children ate was reported. Our findings are not surprising knowing the challenges of memory recall, the cognitive

Table 2: Categories according to how the children self-reported consumption in the dietary recall and the photographs taken before and after the meals. (‘Digital food imaging analysis)
For any particular test result, the probability that it will be

<table>
<thead>
<tr>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.557</td>
<td>0.293</td>
</tr>
</tbody>
</table>

For any particular positive test result, the probability that it is

<table>
<thead>
<tr>
<th>True Positive</th>
<th>False Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.605</td>
<td>0.395</td>
</tr>
</tbody>
</table>

For any particular negative test result, the probability that it is

<table>
<thead>
<tr>
<th>True Negative</th>
<th>False Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.373</td>
<td>0.733</td>
</tr>
</tbody>
</table>

Table 4: Sensitivity, specificity, positive predictive values and negative predictive values for day one, two and three.

Table 5: Sensitivity, specificity, positive predictive values and negative predictive values for the three days.

<table>
<thead>
<tr>
<th>Estimated Value</th>
<th>Estimated Value</th>
<th>Estimated Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>Day 2</td>
<td>Day 3</td>
</tr>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
</tbody>
</table>

Baxter and colleagues [9] evaluated the effect of recency on accuracy of fourth-graders’ dietary reports. They found that children’s dietary reporting accuracy highly depended on the interview time. Others have also found that when the time between the interview and the meal is prolonged, the rate of intrusions, omissions, and temporal dating increases [6,9-11]. Moreover, Arab and colleagues [12] found that children report less accurately when they report more than one meal. Thus, time and meal frequency are factors that can affect the accuracy of the dietary recalls.

Other explanations given for inaccurate reporting is the type and quantity of food consumed and cognitive ability. Memory recall of meals is such that if an unusual meal is consumed from a daily routine it is more likely to be recalled with better accuracy [13] and the difficulty children have estimating the amount of food consumed compared to the amount served has also been documented [14]. Lastly, a frequent explanation given to the inaccuracy is cognitive ability, which Smith and colleagues [15] found was negatively correlated with omission rates (in girls and boys) and intrusion rates (in girls). Many studies, thus, have shown the difficulty children have self-reporting dietary recalls.

But not all studies have shown the inaccuracy of dietary recalls in children. Swedish children six to eight years of age were able to accurately recall their school lunch intake for one meal [16]. This finding suggested that children as young as six years of age may be more able to report on dietary intake than previously reported, at least for one main meal at school. However, only one overweight child participated in the study and overweight children have been shown to under report energy intake to a larger degree than normal weight subjects [17]. The findings of this study, therefore, should not be generalized to larger more diverse populations.

Researchers [18] generally agree that children’s ability to recall food eaten improves in children after seven to eight years of age such that by the age of 12 years children can accurately recall previously eaten food. But Rothausen and colleagues [19] found that 93% of Seven to Eight year old children were acceptable recallers of energy intake versus only 70% of 12-13 year old children.
Parent’s assistance with their child’s dietary recalls has been highly recommended [14,18,20]. Burrows and colleagues [21] concluded that the 24-hour multiple pass recall conducted over a three day period (including weekdays and weekend days) with parent assistance was the most accurate diet assessment method to measure energy intake in children ages four to eleven years when compared to doubly labeled water. Latino mothers, however, were only able to accurately recall 51% of portion sizes of food items their children (four to seven years of age) consumed [22] Mothers accuracy in reporting the number of food items also varied by food group with vegetables items having only 41% accuracy.

Parental assistance was not used for our study and it may not be possible for studies interested in 24-hour dietary intake of children living in poverty. Most children from low-income households participate in the NSLP and they have up to two meals a day during the week in schools. Parents are not present to observe and report what their children consume. Hunsberger and colleagues [19] even found this with Swedish parents when questioned about their children’s dietary intake. Parents had little knowledge of the quantity or food items consumed at school.

As described above, most of the published research supports the inaccuracy of children self-reporting dietary recall. Unless well designed intake methods are aided with technology, dietary recalls may not be of value [23]. The use of digital photography as visual aids to identify and quantify foods has been shown to improve accuracy of dietary intake in children [24]. Digital photography methods such as DFIA might identify more accurately actual food consumed. Estimation of food weight was compared between DFIA and Nutrition Data System for Research software (NDSR; version 4.04). NDSR used 24-hour dietary recalls and DFIA used cameras to collect dietary data of children eight to nine years [25]. Three days of 24-hour dietary recalls were collected the following day and photographs of foods, before and after consumption, were collected on the same day of the analysis. For reference meals were weighed with an electronic scale at the school cafeteria cash register and again at the disposal window to calculate the weight of food consumed. The Pearson’s correlation displayed a stronger correlation between DFIA and real weight (0.592) than NDSR and real weight (0.297).

Another digital photography method is the Interactive Portion Size Assessment System (IPSAS) which used food photographs of child portions [14]. This method had higher agreement with actual weighed food intake than using 24-hour dietary recalls and food models. Other studies have also shown the value of digital photography to assess dietary intake, either alone or in combination with dietary recalls, to improve the accuracy of dietary intake of children [26,27].

A limitation of the present study is that the findings cannot be generalized to the general population of children or even to other Hispanic children because the present study targeted a special children population who are most at-risk—Hispanic children living in low-income households. Another limitation is that 25% of the children were ELL and may have not related appropriate dietary information because of language barriers. All interviewers, however, were bilingual and the interviews were conducted in either English or Spanish or both. The third limitation may have been that the interviewers identified incorrectly the foods in the photographs. But school menus and recipes were made available and all foods were verified using these records. A fourth limitation is that several interviewers were used to obtain self-report data. There may have been interviewer bias in the data collected as no single interviewer could have asked the respondents questions in the same manner. To circumvent this bias interviewers underwent an extensive two day training by a registered dietitian certified by Nutrition Data System for Research and also underwent a third day of certification. Lastly this study would have provided more insight into the diagnostic accuracy of dietary recalls if the validity would have been assessed by age, race/ethnicity, and socioeconomic status. Unfortunately this study included only third and fourth grade students and over 95% of them were minority and economically disadvantaged.

In conclusion Hispanic children living in poverty are most at-risk and methods to conduct nutritional surveillance and to evaluate nutrition programs are absolutely necessary. Common tools used to assess diet are 24-hour dietary recalls. But this study showed that self-reported dietary recalls were inaccurate assessing dietary intake in very young Hispanic children from low-income households. A more promising method is using technology such as digital photography to complement memory recall.

Acknowledgment

This material is based upon work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award number 2011: 67001-30071.

References

12. Arab I, Estrdin D, Kim DH, Burke J, Goldman J. Feasibility testing of an


*Corresponding author: Roberto P. Trevino, Social and Health Research Center, San Antonio, Texas, USA, 78210, Tel: 210-533-8886; Fax: 210-533-4107; E-mail: rtrevino@sahrc.org

Received Date: March 11, 2016, Accepted Date: May 30, 2016, Published Date: June 8, 2016.

Copyright: © 2016 Trevino P, et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.