Short Communication

Novel dietary intake assessment in populations with poor literacy

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Background and Objectives: Cultural and/or environmental barriers make the assessment of dietary intake in rural populations challenging. We aimed to assess the accuracy of a meal recall questionnaire, adapted for use with impoverished South Indian populations living in rural areas. **Methods and Study Design:** Dietary data collected by recall versus weighed meals were compared. Data were obtained from 45 adults aged 19-85 years, living in rural Andhra Pradesh, who were recruited by convenience sampling. Weighed meal records (WMRs) were conducted in the household by a researcher aided by a trained field worker. The following day, field workers conducted a recall interview with the same participant. Eight life size photographs of portions of South Indian foods were created to aid each participant's recall and a database of nutrients was developed to calculate nutrient intake. Pearson correlations were used to assess the strength of associations between intake of energy and nutrients calculated from meal recalls versus WMRs. Least products regression was conducted to examine fixed and proportional bias. Bland-Altman plots were constructed to measure systematic or differential bias. **Results:** Significant correlations were observed between estimates for energy and nutrients obtained by the two methods (r^2=0.19-0.67, p<0.001). No systematic bias was detected by Bland-Altman plots. Recall method underestimated the intake of protein and fat in a manner proportional to the level of intake. **Conclusions:** Our culturally adapted meal recall questionnaire provides an accurate measure for assessment of the intake of energy, macronutrients and some micronutrients in rural Indian populations.

Key Words: food recall, weighed meal record, rural, disadvantage, South India

INTRODUCTION

The assessment of dietary intake in poor communities in India, as in other low-and-middle income countries (LMICs), is challenging. However, accurately assessing the nutritional status of these populations may aid in the development of population specific nutritional interventions.

Weighed food records (WFRs),[1] the gold-standard method for estimating dietary intake, are laborious for participants. WFRs also require participants to have good literacy skills so that food intake over a period of three to seven full days can be accurately recorded.[2] An alternative method, the food frequency questionnaire, also requires literate participants who can complete a questionnaire and who are adept at estimating quantities of food and frequency of intake.[2,3] Neither of these methods would be feasible for use in impoverished and largely illiterate rural communities.

An acceptable alternative is a 24 hour food recall questionnaire administered by trained field workers.[4] Although relatively easy to administer, this method may be subject to misreporting of energy and micronutrient intake.[5] Illiteracy or poor educational attainment of participants, as well as a lack of specific cultural and/or detailed knowledge of local foods on the part of the researchers, can limit the accuracy of data collected by recall.[6-8] These data, however, can be supplemented by directly observing and recording cooking and eating practices.

In this study, we aimed to assess the dietary intake of a rural South Indian community, comprising predominantly illiterate subsistence farmers earning 1,000 to 1,500 rupees per family per month, well below the standard poverty level as defined by the World Bank.[9] We aimed to

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determine their intake of energy and macronutrients, as well as to gain an estimate of the intake of calcium and iron. These were of particular interest given the critically high prevalence of deficiencies of these micronutrients in rural India.[10]

We trained local field workers to obtain an oral record of 24 hour food intake, from each participant, using a specifically designed and culturally appropriate three-pass questionnaire, to capture consumption of local foods. To support the wider use of our three-pass questionnaire we aimed to validate it against WFRs. However, we faced cultural barriers that prohibited our field workers, particularly when female, from visiting households in the afternoon, and evening hours, to observe and weigh meals. For these reasons, we now report a study based not on a full 24 hour recall record, but on the comparison of the content of nutrients of local meals, that were directly weighed and recorded by field workers, versus meals recalled, using our specifically designed questionnaire. These records will be referred to as weighed meal records (WMRs) in this article. We assess bias through the commonly used Bland and Altman method of differences,[13] and ordinary least products regression to estimate both fixed and proportionate bias, between the two methods.[14] We tested the null hypothesis that there is a high level of agreement between the meal recall questionnaire and WMRs, and thus an absence of fixed or proportional bias.

MATERIALS AND METHODS

Ethics

The study was approved by the Human Ethics Committees of Monash University, the Rishi Valley Education Centre and the Indian Council of Medical Research (ICMR). All procedures were in accordance with the Helsinki Declaration of 2000 as revised in 2002.

Study population

The setting for this project was a disadvantaged and largely illiterate community, living in rural villages spread through the Kurabalakota Mandal of the Chittoor District of South India. The language commonly spoken in this community is Telugu.

Recruitment and consent

Participants were recruited from two on-going studies: a case-control study of hypertension and a birth cohort study. Village leaders were informed about the case-control study by the project manager. Subsequently, field workers approached residents door-to-door to recruit potential participants. All individuals aged ≥18 years were eligible. Individuals with high blood pressure were identified as cases, while controls were non-hypertensive individuals matched 1:1 by age and sex. For the birth cohort study, accredited social health activist volunteers recruited women between the age of 15 and 49 years with a confirmed gestational pregnancy of less than 10 weeks gestation, plus the woman's spouse.

For the present study of dietary intake, participants from each of these two studies were approached by field workers. One of the investigators (O.S) then asked whether we could observe their cooking preparations and meal consumption in their home on the following day. The villagers were provided with a full oral explanation of the purpose and methods of our food intake comparison study and were also provided with written material if requested. For those who agreed to participate, informed consent was obtained either via a written signature or, when the participant was illiterate, via a thumb print.

Development of an orally administered 24 hour recall questionnaire

Understanding the local food practices and dietary behaviour of a given population is essential for the successful development of a culturally sensitive dietary tool. Therefore, we first travelled to the local food markets in the Kurabalakota Mandal and took photographs of foods tended for sale. Foods unfamiliar to the researchers were identified by field workers who explained their use and importance in the local diet. In addition, focus group discussions were conducted with field workers and local families to determine food items that were most commonly consumed. These groups also discussed foods eaten during festivals, foods allowed/restricted during periods of fasting, and foods available from local hotels. This information provided the insight required for modification of a conventional 24 hour recall questionnaire[15] to be implemented in a specific South Indian setting of disadvantage.

Discussions with villagers and direct observations during the preparation of meals provided additional valuable information regarding cooking and eating practices in the villages. Women of the household typically start preparing food at approximately 5 am because they usually must travel long distances to their work or are required to begin work early on the farm. Breakfast and lunch meals are both prepared at this time. These meals generally comprise boiled rice served with a lentil or vegetable curry, often presented together with pickles and other condiments on a *thali*, or large plate. Curries prepared in the morning are eaten again for dinner accompanying a fresh pot of rice or newly made *roti* (unleaven bread). A list of the most commonly consumed foods is shown in Supplementary Table 1. This information was used to design the verbal prompts and supplementary dietary tools (see below) for our three-pass 24 hour recall questionnaire.[15] The questionnaire was initially designed in English, then translated into the local language (Telugu) and back-translated to check for translation errors. In studies using this questionnaire, participants typically completed the 24 hour food recall questionnaire on two consecutive days during an interview with a trained field worker. The interview was organised as a three-pass approach. During the first pass, field workers obtained a comprehensive list of all foods eaten during the previous 24 hours, without trying to determine serving size. In the second pass, participants were asked to describe each item of food/drink that they had recalled consuming, including information on the cooking method. For the third and final pass participants were asked to estimate the quantity of each food/drink consumed, plus the amount of food left over. To aid recall, reference food portion size photographs, cooking vessels and standard cups and spoons were made available to participants.

A 1 L measuring jug, six measuring spoons (0.625 mL-

5 mL), twelve standard cooking vessels (20 mL-1000 mL), three cups (100 mL-400 mL), eight photographs of portion sizes (as below), and a visual aid to estimate the size of circular food items such as *roti*, were made available to participants in the study. The standard cooking vessels used were those previously validated by the National Nutrition Monitoring Bureau (NNMB) of Hyderabad.

To further aid food recall we prepared life size photographs of typical South Indian dishes plated on a large *thali* (Figure 1). Representative meals comprising portions of okra, green leafy vegetable, chickpea, and chicken curries around a central mound of boiled rice, were photographed in eight weighed and measured portion

Figure 1 A-H. Photographs of food portion sizes. Panels A-D show rice (125 mL: 250 mL: 350 mL: 500 mL), okra curry, chick pea curry and green leafy vegetable curry (125 mL: 250 mL). Panels E-H show rice (125 mL: 500 mL) and chicken curry (94 g: 137 g: 189 g: 277 g). Colour files may be obtained from the authors.

sizes (125 mL-500 mL; 94 g to 277 g portions of chicken curry). Three *katoris* (small dishes) of dhal curry, *rasam* (tamarind and tomato soup), and a chutney were also placed on the *thali* to complete the traditional appearance of the meal. Importantly, the portions photographed can be used to aid estimation of the amounts of similar types of food consumed. For example, we have photographed portion sizes of a green leafy vegetable curry that can be used to estimate the portion size of any other type of vegetable curry, such as bean, cauliflower, or lentil. Similarly, the portion sizes of rice photographed can be used to estimate intake of noodles, couscous, or risotto.

From food weights and volumes, conversion factors were calculated so that food volumes reported by participants could readily be converted back into grams. Conversion factors were calculated by placing the ingredient/food item in a vessel and dividing the amount of food in grams by the volume in mLs contained in the vessel. Commonly consumed food items, that could be readily estimated in terms of the number of discrete items (eg pieces of fruit or number of small snacks), were not included in these photographs.[16]

The *thali* plates were photographed using a digital video camera (D4 Nikon with a 60 mm Nikkor Macro lens) mounted on a tripod. Photos were taken at 16F from a camera angle of approximately 75°. Food positioning and camera settings were kept standard.

Comparison study of nutrient intake by two methods

To assess the accuracy of the three pass 24 hour recall questionnaire, weighed meals were compared with recalled meals. One investigator (A.K.S) and a trained field worker went to 30 households and observed the morning preparation of meals for each family for the day ahead. The trained field worker then conducted the remaining 15 WMRs alone. All ingredients added to the cooking and all food items consumed and left uneaten were weighed using a kitchen weighing scale (Soehnle, Germany). The amount of food eaten by the participant was then observed at breakfast. For one participant, data were obtained dinner as well as breakfast. The following day participants completed the 24 hour food questionnaire with a trained field worker. Data from a single weighed meal were then compared with data from the same meal as recalled the following day.

Determining nutrient content

The nutrient composition of foods/drinks consumed by study participants were obtained using food composition tables from Andhra Pradesh,[17] or in the few cases where information was unavailable from Indian sources, with data from the USDA National Nutrient Data Base.[18] While current nutrient databases include recipes for foods in western countries and parts of Asia, they do not include the nutrient composition for specific South Indian meals. Therefore, one investigator (A.K.S) collated information from 52 traditional rural South Indian recipes obtained from interviewing field workers. Subsequently, a nutrient database comprising 150 separate foods/drinks and composite food was developed using Microsoft Excel (Office 2013). Constructing this database was essential to the analysis of energy and nutrient intakes for this population because there is no nutrient database, for Indian foods, available for use. Our database provided data for energy content (kJ/100 g), macronutrients (g/100 g) and selected micronutrients (mg/100 g) for raw food items. Since the most commonly consumed foods in this region are rice, dhal and rasam, we added nutritional data for the cooked versions of these food items into the database. Volumes of recalled meals were converted to grams through application of conversion factors (as above). For our study, dietary data were compared between paired weighed and recalled meals from 45 participants.

Data analysis

Data were analysed using STATA (version 10.2). Skewness and kurtosis were measured by observing outliers and the distribution of histograms. Normality was indicated by application of the Shapiro-Wilk test. Normally distributed data are reported as means ± standard deviations (SD) while non-normally distributed date are reported as medians (and 25% and 75% quartile ranges).

We first assessed differences in the mean (Student's paired t-test) and median (Wilcoxon matched-pairs signed-rank test) estimates of energy and nutrient intake, between weighed meals and recalled meals. Bland-Altman plots were then used to assess the presence of systematic bias.[13] Model II ordinary least products regression was conducted to assess fixed and proportional bias.[14] Pearson product moment correlation coefficients were used to assess the level of agreement between energy and nutrient intake calculated by direct meal weighing versus recall.

RESULTS

A total of 45 participants (53% men) provided data for this study. Men had a median age (Q1-Q3) of 52 (28-65) years and median body mass index (BMI) of 19 (21-25) kg/m^2. Pregnant women made up 18% of the survey sample (median age 21 (19.5-24 years)). Non-pregnant women (29%) had a median age of 60 (53-65) years with a median BMI of 18 (19-21) kg/m^2. Approximately 40% of all participants had not completed primary school.

Relative to the WMR, the 24 hour recall questionnaire underestimated the mean intake of carbohydrate (by ~4%) (Supplementary Table 2). We did not detect any other differences in mean or median intake of energy and other macro- and micro-nutrients, between the two methods. Strong linear relationships were observed between energy and nutrient content obtained by 24 hour recall questionnaire compared with WMR, with Pearson product moment correlation coefficients ranging from 0.19 to 0.67 (p<0.001 in each case) (Supplementary Figure 1).

The agreement between the estimates of intake of energy and nutrients determined by the two methods are illustrated by Bland-Altman plots (Supplementary Figure 2). There was low variability between the two methods, with <7% of values lying outside the 1 SD limits for energy, carbohydrate and fibre, and <5% of values outside the 1 SD limits for all other nutrients.

Using ordinary least products regression analysis we were unable to detect fixed bias for any variable (Table 1). Furthermore, the 95% confidence limits of the slopes of the relationships between the two sets of measurements of

Table 1. Outcomes of ordinary least products regression analysis of the weighed meal records versus 24 hour recall questionnaires

Variable	r^2	*p* value	Y intercept	Slope
Energy	0.283	<0.001	0.18 (-0.77-1.13)	0.84 (0.53-1.16)
Protein	0.193	<0.001	3.58 (-0.81-7.97)	0.67 (0.45-0.88)
Fat	0.429	<0.001	1.97 (-0.49-4.42)	0.76 (0.56-0.95)
Carbohydrate	0.394	<0.001	-10.2 (-51.3-31.0)	0.94 (0.69-1.19)
Fibre	0.489	<0.001	-0.02 (-0.98-0.93)	1.09 (0.83-1.35)
Calcium	0.673	<0.001	18.6 (-7.03-44.1)	0.88 (0.72-1.04)
Iron	0.578	<0.001	0.04 (-1.10-1.18)	0.98 (0.77-1.19)

r^2=Pearson product moment correlation coefficient. P tests the hypothesis that the slope of the line differs from zero. The y-intercept and slope are given as the estimate followed by 95% confidence limits in parentheses. Refer to Supplementary Figure 1.

energy, carbohydrate, fibre, calcium, and iron included unity, indicating the absence of proportional bias. However, the slopes of the relationships for protein and fat were significantly less than unity. Thus, the 24 hour recall questionnaire method systematically underestimated intake of these nutrients in a manner proportional to the level of intake of the nutrient.

DISCUSSION

Our findings indicate that our meal recall questionnaire, accompanied by culturally appropriate visual aids, provides a reliable measure of intake of energy and macro- and micro-nutrients for single meals consumed by a rural disadvantaged Indian population. Our findings extend those presented in previous studies because we (i) applied our questionnaire to a representative population of men and women (including pregnant women), and (ii) quantified the nature of bias associated with our questionnaire so that data collected in the future using this method can be adjusted to provide an accurate assessment of daily intake.

We utilised a number of measures to assess the accuracy of the assessment of one meal using a culturally modified recall questionnaire. Firstly, Bland-Altman plots of energy and nutrient intakes estimated by the two methods showed relatively good agreement between data generated by meal recall and WMRs. Secondly, correlation analysis showed that linear relationships between measurements obtained by WMR and the recall questionnaire explained reasonable proportions of the variance in the data set, particularly given the difficult social setting (r^2=0.19-0.67). However, a statistically significant difference was evident between the mean intakes of carbohydrate as computed from the recall of one meal compared with the WMR. Furthermore, our findings suggest that, when used to estimate intake of nutrients, our recall questionnaire would under-estimate the intake of protein and fat in a manner proportional to the total level of intake (proportional bias).

Importantly, having quantified the relationships between intake of protein and fat generated using WMR versus recall methods, future measurements obtained using our *full* 24 hour recall questionnaire can be corrected. We concede that this is a difficult assertion to substantiate, given our inability to weigh all foods consumed throughout the day due to the specific cultural practices of the population we studied. To ensure the dependability of our data, further research should be conducted in similar populations. Nevertheless we did not detect any systematic bias between the two methods from Bland-Altman plots. Additionally, we provide evidence for a good agreement between intakes of energy, macro and micro-nutrients using Pearson product moment correlation coefficients. Together, these findings support our argument that, when correction factors are applied to our 24 hour recall questionnaire, intake of energy, carbohydrate, fibre, calcium, and iron, will be relatively accurate.

We were able to detect systematic differences, between data obtained from WMR and recall on protein and fat intakes, using ordinary least product regression but not by paired t-test/signed-rank test. Conversely, we detected a systematic difference between data collected using the two methods of assessment for carbohydrate intake using paired t-test, but not by regression analyses. These apparent disparities likely arise from the fact that these statistical methods assess different characteristics of the sample. Specifically, Student's paired t-test compares means and the signed rank test compares medians. In contrast, ordinary least products regression dissociates the contributions of fixed and proportional bias to systematic differences in the paired values. For example, our inability to detect significant differences in the median values of protein and fat intake determined by 24 hour recall compared with WMR does not invalidate our conclusion, derived from regression analysis, that the 24 hour recall method has bias. Rather, it shows that the proportional bias that could lead to underestimation of protein and fat intake using 24 hour recall questionnaire is accompanied by a tendency for fixed bias (albeit not statistically significant) that might lead to over-estimation of the intake of these nutrients when intake is low. Similarly, our inability to detect significant proportional or fixed bias between 24 hour recall and WMR using regression analysis does not invalidate our conclusion, based on comparison of medians, that 24 hour recall under-estimates carbohydrate intake. Rather, it likely reflects a type 2 error. That is, our sample of 45 people may have been insufficient to dissect out the relative contributions of fixed and proportional bias to this under-estimation.

In the Pune study, investigators successfully modified the 24 hour recall tool in a rural South Indian population. However, they limited its implementation to the nutritional assessment of pregnant women. In their study of 41 pregnant women in rural south India, focus groups on local food habits were used to provide input for modification of a 24 hour recall questionnaire.[6] They reported a high level of agreement between estimates of energy, protein, and fat intake between the 24 hour dietary recall questionnaire and WFRs. However, the fact that they were unable to detect a significant difference between these two methods may be due to the marginally smaller sample studied compared to ours. Additionally, no assessment of intake of micro-nutrients was included in the study. This is surprising considering the prevalence of deficiencies of micronutrients in India is so great.[10] Finally, although they assessed bias using the Bland and Altman's method of difference,[13] no method was employed to quantify the relationships between the measures obtained with the two methods. Ordinary least products regression is ideally suited for this purpose, since it can detect both fixed and proportional bias.[14]

Some of our conclusions contrast with those of Rao et al generated from data from the Pune study.[6] Our findings indicate that meal recall underestimates intake of protein and fat from one meal compared with WMRs, particularly when intake is high. In contrast, Rao et al concluded that there are little or no systematic differences between estimates of protein and fat determined using 24 hour recall questionnaire compared with WFR. The apparent disparity in our findings may in part be attributable to the different analytical methods used. In particular, we detected bias using ordinary least products regression analysis but Rao et al did not apply this method. However, methodological differences in capturing data, between the two studies, might also have contributed to the disparity in our findings and conclusions. We were unable to conduct observations for a full day because of the cultural barriers against female field workers visiting households in the afternoon and evenings. Consequently, it was not possible for us to make specific comparisons, between the two methods for assessing diet, across the entire day. Rather, our analysis included data collected for only one meal. Thus, the bias we found in estimates of protein and fat may be applicable to meals early in the day, but not the evening meal. An additional limitation of our study was the use of a single resource for calculating energy and nutrient intakes for the sample. This resource was a database of nutrients specifically developed for the analysis of South Indian diets, based on the edible portion of raw foods for all foods except rice, dhal and rasam. In contrast, in the Pune study, 25 major food items were collected and their nutrient content was directly analysed.[6] Consequently, in the current study water losses during cooking were not accounted for, which would influence the calculated content of macronutrients such as carbohydrates.

There were a number of strengths to this study. Firstly, we had a sample size of 45 individuals, which is greater than the sample size of 41 women used in the Pune study. Secondly, dietary analyses were only conducted on data from food items reported from 24 hour recall questionnaires, which were weighed the day before by WMRs. This mitigated the limitation imposed by the fact that we only weighed a single meal. Thus, it allowed analysis of paired measures using the two methods of dietary assessment. Furthermore, the WMR method procedure is a valid reference method because it was conducted following the same strict protocol used when conducting WFRs.[19] Taken together, this provides evidence that a 24 hour recall questionnaire, accompanied by culturally appropriate visual aids, can facilitate the accurate collection of dietary data from individuals with poor education levels. This novel method of dietary assessment can be applied to other populations with similar educational attainment.

Conclusion

In conclusion, we demonstrate that cultural modifications made to the traditional recall questionnaire can aid the collection of accurate dietary data in a rural setting. Though we only show data from one meal collected by meal recall, compared against a WMR, we are confident that when extended to a 24 hour record, this method can be used to assess daily dietary intake and identify potential inadequacies in energy and nutrient intake, in a disadvantaged setting. This culturally appropriate verbally administered 24 hour recall questionnaire should be extremely useful for assessment of nutrition in mostly illiterate communities around the World. Information generated from implementation of this questionnaire can assist formulation of public health policies in India and potentially in other parts of the World where education and literacy levels are poor.

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REFERENCES

1. Gittelsohn J, Shankar AV, Pokhrel RP, West KP, Jr. Accuracy of estimating food intake by observation. J Am Diet Assoc. 1994;94:1273-7. doi: 10.1016/0002-8223(94)92459-7.
2. Vucic V, Glibetic M, Novakovic R, Ngo J, Ristic-Medic D, Tepsic J, Ranic M, Serra-Majem L, Gurinovic M. Dietary assessment methods used for low-income populations in food consumption surveys: a literature review. Br J Nutr. 2009;101(Suppl 2):S95-101. doi: 10.1017/S0007114509990626.
3. MacIntyre UE, Venter CS, Vorster HH. A culture-sensitive quantitative food frequency questionnaire used in an african population: 1. Development and reproducibility. Public Health Nutr. 2001;4:53-62. doi: 10.1079/PHN200040.
4. Sharma M, Rao M, Jacob S, Jacob CK. Validation of 24-hour dietary recall: a study in hemodialysis patients. J Ren Nutr. 1998;8:199-202. doi: 10.1016/S1051-2276(98)90018-8.
5. Poslusna K, Ruprich J, de Vries JH, Jakubikova M, van't Veer P. Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice. Br J Nutr. 2009;101(Suppl 2):S73-85. doi: 10.1017/S0007114509990602.
6. Rao S, Kanade AN, Joshi SR, Yajnik CS. Community-specific modifications are essential for objective assessment of maternal dietary intake--pune maternal nutrition study. Public Health Nutr. 2009;12:1470-6. doi: 10.1017/S1368980008004424.
7. Natarajan VS, Ravindran S, Sivashanmugam, Thyagarajan, Kailash K, Krishnaswamy B, Suresh B, Prabhu P.

Assessment of nutrient intake and associated factors in an indian elderly population. Age Ageing. 1993;22:103-8. doi: 10.1093/ageing/22.2.103.
8. Solomons NW, Valdes-Ramos R. Dietary assessment tools for developing countries for use in multi-centric, collaborative protocols. Public Health Nutr. 2002;5:955-68. doi: 10.1079/PHN2002390.
9. Haughton J, Khandker, S. Handbook on poverty and inequality. Washington, DC: The International Bank for Reconstruction and Development/The World Bank; 2009.
10. National Nutrition Monitoring Bureau. Diet and nutritional status of population and prevalence of hypertension among adults in rural areas. NNMB Technical Report No 24. Hyderabad: National Institute of Nutrition/Indian Council of Medical Research; 2006.
11. Thrift AG, Evans RG, Kalyanram K, Kartik K, Fitzgerald SM, Srikanth V. Gender-specific effects of caste and salt on hypertension in poverty: a population-based study. J Hypertens. 2011;29:443-50. doi: 10.1097/HJH.0b013e3283 41888c.
12. Subasinghe AK, Walker KZ, Evans RG, Srikanth V, Arabshahi S, Kartik K, Kalyanram K, Thrift AG. Association between farming and chronic energy deficiency in rural south india. PloS One. 2014;9:e87423. doi: 10.1371 journal. pone.0087423.
13. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;1:307-10. doi: 10.1016/S0140-6736(86)9083 7-8.
14. Ludbrook J. Linear regression analysis for comparing two measurers or methods of measurement: but which regression? Clin Exp Pharmacol Physiol. 2010;37:692-9. doi: 10.1111/j. 1440-1681.2010.05376.x.
15. Gibson SR. Principles of nutritional assessment. New York: Oxford University Press; 2005.
16. Haraldsdottir J, Tjonneland A, Overvad K. Validity of individual portion size estimates in a food frequency questionnaire. Int J Epidemiol. 1994;23:780-96. doi: 10. 1093/ije/23.4.787.
17. Gopalan C, Rama Sastri BV, Balasubramanian SC. Nutritive value of indian foods. Hyderabad, India: National Institute of Nutrition, Indian Council of Medical Research; 1989.
18. Agricultural Research Service. USDA national nutrient database for standard reference. Beltsville, Maryland: Nutrient Data Laboratory; 2011.
19. Bingham SA, Gill C, Welch A, Day K, Cassidy A, Khaw KT, Sneyd MJ, Key TJ, Roe L, Day NE. Comparison of dietary assessment methods in nutritional epidemiology: Weighed records v. 24 h recalls, food-frequency questionnaires and estimated-diet records. Br J Nutr. 1994;72:619-43. doi: 10.1079/BJN19940064.

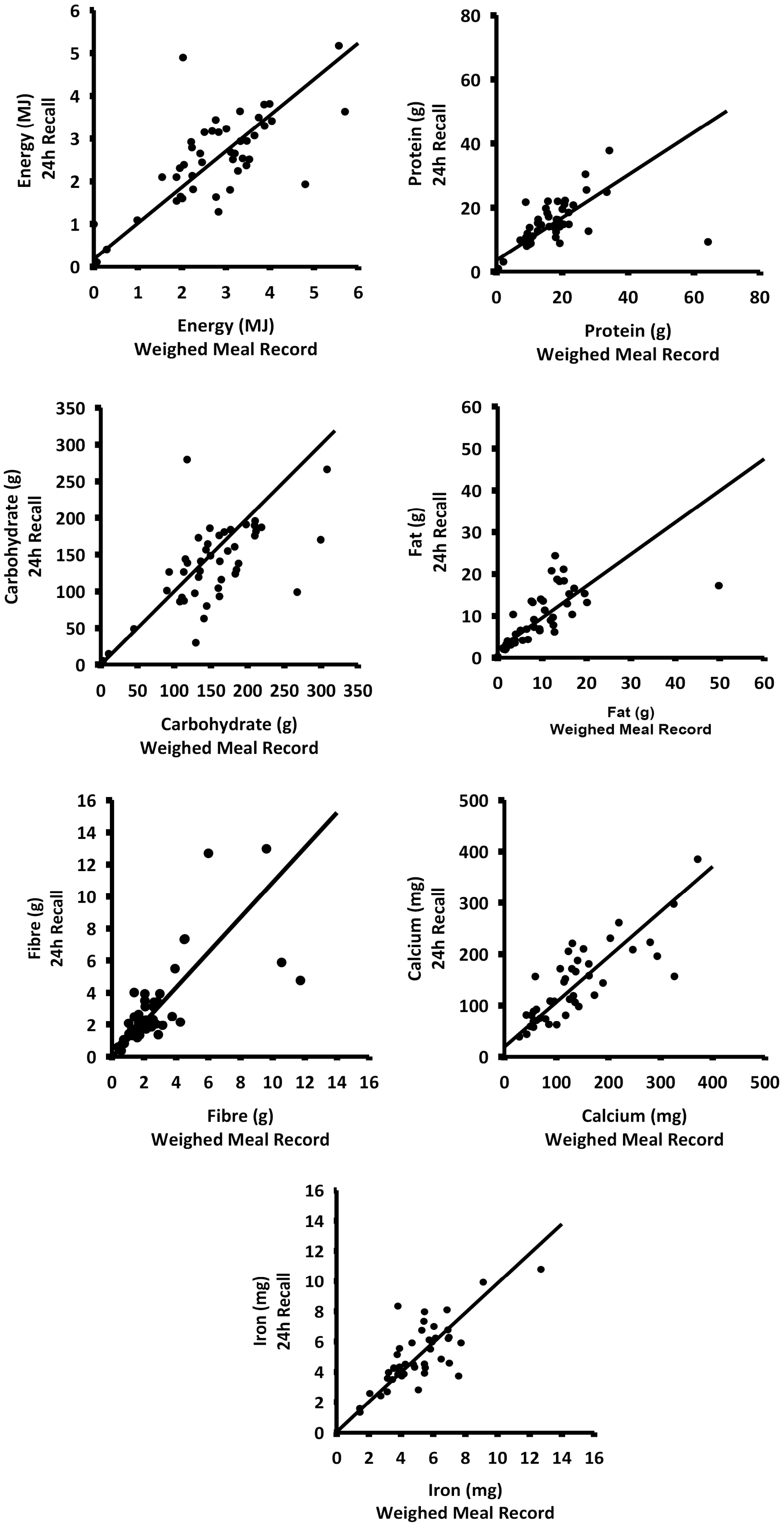
Supplementary Table 1. Foods commonly consumed in The Rishi Valley, South India

Category of food items	Food items
Cereals and millets	*Ragi mudde* (balls of finger millet porridge) , *idli* (steamed cakes of rice) and *dosa* (pancakes of rice and fermented lentils), *pongal* (a sweet or spicy porridge of rice and lentils), *upma* and *rava* (semolina porridge or pancakes), *roti* and *chapathi* (wholemeal unleaven bread*)*
Pulses	Lentils, horse-gram, red-gram, green-gram, black-gram, Bengal-gram, hyacinth beans, chickpeas, *sambar* (lentil stew)
Milk & milk products	Milk, curd, yoghurt, buttermilk, *ragi malt* and *badam milk* (milk thickened with finger millet flour or almond paste, respectively), tea, coffee
Vegetables	Okra, potatoes, tomatoes, green beans, broad beans, onions, beetroot, radish, cabbage, pumpkin, bitter gourd, ridge gourd, snake gourd, green peas, carrot, drumstick, eggplant, coriander
Soup	Tamarind rasam
Non-vegetarian	Curry (made with chicken, mutton, beef, pork, or fish), egg omelettes
Chutneys	Coconut, groundnut, tomato, or tamarind
Fruit	Bananas, mangoes, apples, custard apple, watermelon, coconut, oranges, blackberries, grapes, *sapota (chiku)*, plantain
Condiments and spices	Amaranth leaves, curry leaves, bay leaves, cardamom, coriander seeds, coriander powder, turmeric powder, tamarind, chilli powder, curry powder, dried red chillies, green chillies, peppercorns, rosella hemp chutney, mango pickle, lemon pickle, tamarind chutney, groundnut chutney, tomato chutney, fenugreek seeds, mustard seeds
Oil	Vegetable oil, palm oil, rapeseed oil, canola oil, ghee, butter
Beverages	Coffee, tea, coconut water, orange juice, sweetened soda drinks (Pepsi®, 7up®)
Sweets	*Besan barfi* (chickpea fudge), *kheer* (rice pudding), ice cream, *gulab jamun (balls of milk powder paste, sweetened and deep fried)*, sago pudding, fruit salad, *payasam* (rice, wheat or vermicelli stewed in milk)
Snacks	*Vada* (lentil and potato fritters), *bonda*, and *chilli bonda*, (potato/vegetables coated in lentil flour and deep fried), biscuits, *mur mur*(puffed rice), *murukulu* (deep fried extrusions of lentil and rice flour dough), *pani puri*, (deep fried bread rounds filled with spiced potato) *pakora* (deep fried fritters of vegetables and lentil flour), *masala dosa* (rice and lentil flour pancakes filled with vegetables)

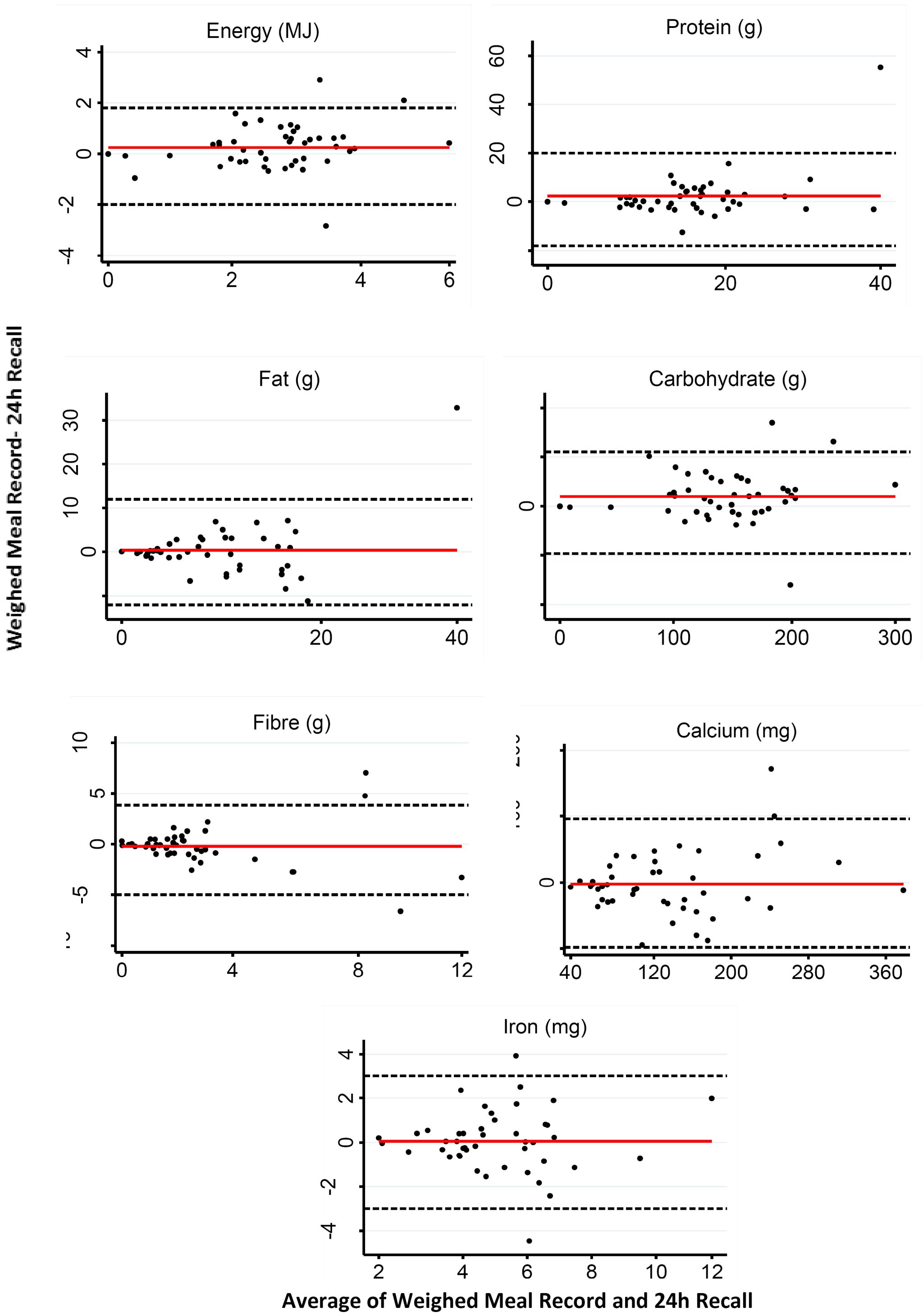
Supplementary Table 2. Comparison of energy and nutrient intakes from 24 hour recall and weighed meal records in 45 adults from a disadvantaged South Indian population

	Median (Q1-Q3)		*p* value
	Weighed meal record	24 hour recall	
Energy (MJ)†	2.8 (1.2)	2.5 (1.0)	0.29
Protein (g)	17.1 (10.6-20.6)	14.5 (10.6-19.4)	0.15
Fat (g)	8.3 (3.8-13.0)	7.7 (3.8-13.4)	0.85
Carbohydrate (g)†	154.1 (60.2)	134.6 (56.5)	0.01
Fibre (g)	2.1 (1.5-2.9)	2.2 (1.7-3.4)	0.13
Calcium (mg)	118.8 (63.1-163.2)	117.8 (79.9-179.8)	0.41
Iron (mg)	4.9 (3.8-6.1)	4.5 (3.8-6.2)	0.80

Q1, Quartile 1 (25th percentile); Q3, Quartile 3 (75th percentile).
†These data are normally distributed and so data are reported as means and standard deviations. *P* values were computed by Student's paired t test for normally distributed data and by Wilcoxon matched-pairs signed-rank test for non-normally distributed data.



Supplementary Figure 1. Relationships between estimates of dietary intake determined by weighed meal record and 24 hour recall questionnaire. Lines of best fit were determined by ordinary least products regression analysis. Regression coefficients and Pearson product-moment correlation coefficients are shown in Table 1.



Supplementary Figure 2. Bland-Altman plots of the mean difference (red lines) in energy and nutrient intake data obtained by weighed meal record and 24 hour recall questionnaire with 95% limits of agreement (broken lines).

Short Communication

Novel dietary intake assessment in populations with poor literacy

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評估讀寫能力較差族群飲食攝取的新穎方法

背景與目的：文化與/或環境障礙是評估農村人口飲食攝取的挑戰。我們的目地為評估一份適用於居住在貧困的南印度農村人口的餐食回憶問卷的正確性。**方法與研究設計：**飲食資料以回憶法及膳食秤重法收集並比較。資料來自於 19-85 歲居住在 Andhra Pradesh 農村的 45 名便利取樣的成人。由一名研究者加上受過訓的田野工作者的協助，在家戶中進行膳食秤重紀錄（WMRs）。翌日，田野工作者會進行同一位參與者的回憶訪視。有八個實際尺寸的南印度食物份量圖片被用以輔助參與者回憶，一個營養素資料庫用以計算營養素攝取量被發展。以皮爾森相關評估膳食回憶法及 WMRs 所計算的熱量及營養素攝取相關強度。以最小積差迴歸評估固定的及比例的偏差。Bland-Altman 圖被用以以測量系統或差別偏差。**結果：**兩種方法所計算的熱量及營養素有顯著相關性（r^2=0.19-0.67，p<0.001）。Bland-Altman 圖沒有發現系統性偏差。回憶法在蛋白質及脂肪攝取量有等比例低估的情形。**結論：**在印度農村族群，因應文化的餐食回憶問卷可提供評估熱量、巨量營養素及部分微量營養素的正確測量。

關鍵字：飲食回憶、餐食秤重紀錄、農村、缺點、南印度