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Assessing individual dietary intake from common-plate meals: a new tool for an enduring practice

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Abstract

Objective: The purposes of the present study were to estimate individual intake from common-plate meals among Bedouin Arabs using a modified 24 h recall questionnaire, and to evaluate reported energy intake (EI) by comparison with estimated energy requirement (EER).

Design: Weighed records were used to develop a method of quantifying intake from common plates. Reported EI and nutrient intakes were obtained from administration of the modified 24 h recall. The relative standard error (RSE) was used to evaluate the reliability of reported nutrient intakes. The FAO/WHO/United Nations University and Oxford equations and reported physical activity levels were used to compute ratios of reported EI to BMR and EER.

Setting: Population centres of traditionally semi-nomadic Bedouin Arabs undergoing sedentarization/urbanization in southern Israel.

Subjects: A convenience sample of 451 adults (aged 19–82 years).

Results: Mean (SE) energy intake was 9648 (276) kJ/d (2306 (66) kcal/d) for men and 8230 (172) kJ/d (1967 (41) kcal/d) for women, of which carbohydrates accounted for 63–64 %. The nutrient intakes evaluated had RSE ratios of less than 25 %. EI:EER ratios ranged from 0·86 to 0·89, and from 0·87 to 0·93 among non-dieters who ate the usual amount on the recall day.

Conclusions: The modified 24 h recall produced plausible estimates of energy and nutrient intakes, comparable to those obtained with the 24 h recall in other populations. The modified questionnaire makes an important contribution to facilitating large-scale nutritional surveillance in the Bedouin population, and may serve as a model for modifying dietary instruments to quantify individual intake in other populations that practise common-plate eating.

Keywords
Dietary assessment
24 h recall
Common-plate eating
Bedouin Arabs
Israel

The Negev Bedouin Arabs in southern Israel, a traditionally semi-nomadic population, historically ate their meals from common plates. Despite the processes of sedentarization, modernization and urbanization that have occurred in this population over the past 50 years, common-plate eating remains an enduring practice. Dietary surveillance among Negev Bedouin Arabs has been hampered by the lack of an appropriate dietary assessment instrument for quantifying intake at the individual level[1], thus current comprehensive nutrient intake data for this population are lacking.

Common-plate eating occurs in many parts of the world, but little work has been done to develop dietary assessment methods for quantitatively measuring individual food intake that are practical for use in epidemiological studies[2–4]. The 24 h recall questionnaire is the main tool for dietary surveillance and monitoring dietary intake over time[5,6]. It is based on identifying foods eaten and their portion sizes served and eaten individually in a 24 h period preceding the interview. The traditional 24 h recall is not designed to measure food intake in societies in which common-plate eating is practised.

During recent decades, chronic disease rates among the Bedouin have been on the increase[7–10], as they have in many of the populations that practise common-plate eating[11,12]. Thus, the development of appropriate dietary assessment instruments that are practical for use in large-scale dietary surveillance has become increasingly important. To the best of our knowledge, no dietary assessment tool has ever been adapted and/or used for

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measuring individual food intake in this population. In the present paper, we describe the modification of the 24 h recall for quantifying individual intake from common-plate meals, present the results from the administration of the modified 24 h recall among a sample of Bedouin adults, and compare reported energy intakes (EI) with estimated energy requirements (EER) derived from the calculation of BMR and reported physical activity levels (PAL).

Population and methods

The population and food culture

The history and characteristics of the Bedouin Arabs living in the Negev desert in southern Israel have been described elsewhere[9,13,14]. When the Bedouin Nutritional Study (BNS) was conducted (2001–3), the Negev Bedouin population numbered 138 000 of whom 60 % lived in government-planned towns. The remaining 40 % lived more traditionally in unrecognized villages not connected to local and national planning and communications infrastructures. The Negev Bedouin have the lowest socio-economic level of any population group in Israel, reflected in educational, employment and income levels[15,16].

Traditionally, Bedouin food culture was well adapted to a semi-nomadic life which involved seasonal migration and living in tents with limited household utensils that were easy to transport. The most common traditional meal patterns consisted of either one main dish served on a large platter or of one or more dishes of cooked foods or salads in common service dishes. Main dish meals were usually eaten with the hand, and the rules of hygiene required that a person eat only from the part of the plate directly in front of him/her. In the second type of meal, bite-sized portions of flat bread were used as utensils for dipping in or scooping up food from common service dishes. The bread was consumed along with the food it held. Since many of the foods eaten from common plates with bread were sauce-like or liquid, it was not possible for a person eating with others to visualize how much he or she consumed individually.

Due to the absence of 40 % of the population from census data, the use of standard methods of drawing a random sample (e.g. street addresses from voter registration lists, telephone directories, etc.) would have systematically excluded all those who live in settings that lack official mapping/street addresses and land-line telephones. To obtain a sample that included Bedouin from both recognized and unrecognized localities, we drew the study population from healthy Bedouin adults visiting patients at Soroka University Medical Center, the only regional hospital serving the southern (Negev) region of Israel, and adults (primarily women) attending Maternal and Child Health Care clinics in Bedouin towns. The hospital and clinics serve the Bedouin from both the government-planned towns and the surrounding unrecognized villages, and thus provided us with access to a broad geographical cross-section of the population.

We enrolled adults aged 19 years and above who consented to provide dietary intake information. Data were collected on all days of the week, including weekend days.

Updating the food and nutrient database

The S. Daniel Abraham International Center for Health and Nutrition food composition tables, which are currently based on the US Department of Agriculture (USDA) Nutrient Database for Standard Reference Release 19, were modified to include Israeli-manufactured foods and common recipes[17], but did not include Bedouin foods. We recorded recipes in homes of Bedouin women who cooked a dish, while the research team member weighed and measured the ingredients using digital scales and standardized measuring tools. Cooking times were recorded, and foods were weighed before and after cooking. We thus added 145 Bedouin recipes/foods/beverages to the database prior to beginning and throughout the dietary assessment process. Recipes were calculated using another computer system we developed based on the concept of the American Food Information Analysis System (FIAS) program[18]. Trained nutritional data entry coders did the data entry.

Quantifying food intake

Field tests were conducted in eleven households in three different Bedouin communities to determine what quantifiable information Bedouin could give us on their food intake at the individual level. Foods and beverages eaten in individual servings (e.g. pieces of fruits, sandwiches, meat not in stews) were easily quantified using the USDA method[19]. Respondents were also able to estimate the quantity of bread they ate, since generally people take portions of bread (e.g. a half or whole pita), which they consume individually. Since bread is used as the utensil for eating from common plates, it also serves as the vehicle determining the amount of the common-plate foods consumed, and could thus be used as the means for quantifying the intake of these foods. To determine the 'carrying capacity' of bread for common-plate foods of different consistencies, the BNS Bedouin study staff were trained to conduct weight tests under natural eating conditions among a pool of volunteers recruited from their nuclear and extended families by weighing the bread and common-plate food before and after a meal in which a single common-plate dish was served. Weighings were conducted among adults in five field locations in both urban and rural settings. Multiple weighings of twenty-eight common-plate foods of differing consistencies were carried out in a total of seventeen households. Analysis of these data showed that most common-plate foods fell into two main categories: A,

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solid/semi-solid (e.g. egg dishes, humus salad, semi-solid dips, sauces containing chunks of meat and/or vegetables, thick cracked-wheat or lentil sauces); and B, liquid (e.g. buttermilk sauces, thin vegetable sauces made with potherbs not containing solid chunks). Aggregated averages of the weight data were used to establish the 'carrying capacity' of bread, expressed as food:bread ratios, for these two categories of foods (category A, 1·3 g food:1·0 g bread; category B, 1·0 g food:1·0 g bread). During the pilot and throughout the BNS data collection, the Bedouin BNS study coordinator and a registered dietitian reviewed the results produced by the food:bread ratios. For foods with different/unique consistencies (e.g. dried thyme mixed with olive oil) or for which the standard food:bread ratios produced implausible results, additional weighings were conducted under natural eating conditions and specific food:bread ratios set.

Modification of the US Department of Agriculture 24 h recall questionnaire

The USDA 24 h recall questionnaire was modified to allow for recording of the three eating practices of the population: (i) eating an item as an individual portion; (ii) eating from a common-plate with bread; or (iii) eating directly from a large platter. We used the multi-pass method[19] to administer the modified USDA 24 h recall questionnaire. At the appropriate stage, the interviewers determined which foods were eaten together in one sitting and whether the foods had been consumed with bread as the utensil, individually or with others eating from the same dishes. All items consumed with bread from common plates in a single meal were enclosed by brackets. The total amount of bread the respondent consumed during that meal was obtained.

To estimate the portion size for each of the foods eaten with bread as the utensil in multi-dish meals eaten with others, the interviewer asked if the respondent ate a relatively smaller, medium or larger portion (or equal portions) from each dish. The total amount of bread was then divided by the relative portions given, using 1 for small, 2 for medium and 3 for large. The quantity of food eaten from each dish was calculated on the basis of the food:bread ratio for the consistency category of the food (as described above), and multiplied by the amount of bread (in grams) eaten with each dish.

For meals eaten from a single large common platter, pictures with different relative portions removed from the platter were used as reporting aids. Portion sizes for items consumed individually, rather than from common plates, were reported in the standard way.

The modified 24 h recall questionnaire was piloted among forty Bedouin adults. The results confirmed that individuals were able to estimate the amount of bread they ate at a meal and were able to estimate the relative proportion they consumed from each dish of a common-plate meal with bread.

Administration of the modified 24 h recall

Trained interviewers conducted the interviews in Arabic using a USDA food book and a food models/portion-size booklet modified to include common Israeli foods and Bedouin foods, utensils and portion sizes. Upon completion of the 24 h recall, a number of questions on general health status were asked, a physical activity questionnaire was administered, and the respondents' weight (in light street clothing) and height were measured using a portable digital scale and collapsible measuring stick. Two additional 24 h recalls were completed on non-consecutive days among a subsample of forty respondents who agreed to be interviewed at home.

Quality control

Quality control was applied at four stages. First, each interview was checked for missing data within 1–3 d of the interview. Second, after data entry, the BNS study coordinator, who had extensive knowledge of Bedouin foods and the process for quantifying intake from common plates, edited each questionnaire for accurate data entry and appropriate application of the common-plate quantification method. Requests for corrections were then returned to the coders and re-checked. At the third stage, registered dietitians edited each questionnaire, returned corrections to the coders and re-checked corrected data entries; and, at the final stage, the BNS study coordinator and registered dietitians made cross-interview checks to detect unusual nutrient or food model values.

Physical activity levels

We used a physical activity questionnaire based upon a synthesis of previously validated international questionnaires[20–22], modified for use in Israel[23]. It included questions about the time spent in and intensity of work, recreational, leisure-time and household activities, further modified to capture specific activities associated with Bedouin lifestyle (e.g. herding, washing clothes by hand). The definitions of the joint FAO/WHO/United Nations University (UNU) report on human energy requirements[24] were used to classify physical activities as sedentary/light (non-strenuous occupations, no regular leisure-time or lifestyle-required physical exercise); active/moderately active (moderate occupational exertion or moderate/vigorous leisure activity ≥1 h/d); or vigorously active (very strenuous occupational or leisure activities several hours daily).

Statistical analysis

Descriptive statistics were used to provide a profile of the sample's demographic characteristics, eating patterns and nutrient intakes. We tested for differences in eating patterns by categorical demographic variables using the χ^2 statistic and by continuous demographic variables using Student's t test. Following the method of the National Health and Nutrition Examination Survey (NHANES) 1999–2000, we used a relative standard error (RSE; ratio of

Table 1 Selected characteristics of the Bedouin Nutrition Study participants (*n* 451)

Demographic characteristic	*n* or Mean	% or SD
Women*	302	67·0
Age (years)†	33·8	10·3
Education (years)†,‡	8·4	4·0
BMI (kg/m^2)†	26·0	4·7
Urban settlement*	293	65·0
Amount of food eaten on recall day*		
Usual amount	349	77·4
Less than usual	83	18·4
More than usual	19	4·2
Currently dieting*	35	7·8
Pregnant or breast-feeding*	162	36·1
Taking a vitamin supplement*	72	16·1
Eating patterns		
Number of eating occasions per questionnaire†	5·07	1·8
Total number of items per questionnaire/d†	14·0	4·1
Questionnaires with one or more common-plate eating occasions*	396	87·8

*Data presented are *n* and %.
†Data presented are mean and SD.
‡Data available for 108 men and 119 women.

the standard error of the mean to the mean, multiplied by 100) of greater than 25 % as the statistical criterion to define unreliable nutrient intake estimates[25]. To evaluate the plausibility of the reported EI obtained from the modified 24 h recall questionnaire, we calculated the EER using the FAO/WHO/UNU equations[24], which are based on the Schofield equations[26], to estimate the BMR, and then multiplied it by the appropriate PAL factor based on respondents' reported levels of physical activity. The PAL factors were 1·53, 1·76 and 2·25 for sedentary/light activity, active/moderately active or vigorously active lifestyles, respectively, as defined by the FAO/WHO/UNU report on human energy requirements[24]. The respondents' reported EI was then divided by their EER to obtain the EI:EER ratio. Owing to concerns that the Schofield equations overestimate BMR in non-European populations, the Oxford equations[27] were developed based upon a database of measured BMR data that included a better representation of Asian and other non-European populations. Thus, we also used the Oxford equations to calculate the BMR and EI:EER ratios for our sample. Women who indicated that they were pregnant and breast-feeding on the questionnaire were excluded from this analysis. Student's *t* tests and ANOVA were used to determine whether or not mean EI:EER ratios differed by sex, BMI (above or below median BMI), dieters and non-dieters, and reported eating of 'usual amount' on the day covered by the 24 h recall. Among the forty respondents who completed three repeat 24 h recalls, we computed the within-person CV for selected nutrients to assess the level of day-to-day variability in nutrient intakes using Generalized Estimating Equations (GEE) in the STATA statistical software package version 9·2 (StataCorp LP, College Station, TX, USA). All other statistical analyses were conducted using the SPSS statistical software package version 14·0 (SPSS Inc., Chicago, IL, USA), using $P < 0{\cdot}05$ to indicate significance.

Results

The total BNS sample included 519 participants. We excluded forty-five respondents interviewed during the Islamic month of Ramadan who were fasting from sunrise until sunset. Of the remaining participants, 451 (95 %) completed at least one reliable 24 h recall and were included in the analysis.

The demographic characteristics of the sample are presented in Table 1. The respondents' age distribution ranged from 19 to 82 years with a mean of 34 years. Only 3 % of the sample had BMI below 19·0 kg/m^2, while over 40 % had BMI above 26·0 kg/m^2. More than 75 % of participants reported eating the usual amount on the day of dietary recall, and approximately 8 % reported currently dieting. The proportion who reported taking a vitamin supplement was low, and was concentrated among women who were pregnant or breast-feeding. In the remainder of the sample (*n* 286), only 6·3 % reported using vitamin supplements.

With regard to eating patterns, 88 % reported eating at least one common-plate meal, and this proportion was higher among those living in rural (94 %) than in urban (85 %) communities ($\chi^2 = 7{\cdot}82$, df = 1, $P = 0{\cdot}005$). Those who reported eating common-plate meals did not differ significantly by sex, age or years of education from those who did not report eating common-plate meals.

Table 2 contains the means, standard errors and medians for the dietary intakes of selected nutrients for men and women. All intake estimates have RSE ratios of less than 25 %. Carbohydrate intake accounted for ~63 % of total energy.

Table 3 presents the mean EI for men and women (excluding pregnant and breast-feeding women) and EER calculated using the FAO/Schofield and the Oxford equations and respondents' reported PAL. Low proportions

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Table 2 Dietary intake of selected nutrients among Bedouin men and women in the Bedouin Nutrition Study

	Men (*n* 149)			Women (*n* 302)		
	Mean	SE	Median	Mean	SE	Median
Energy (kJ/d)	9653	275	9665	8234	171	7836
Energy (kcal/d)	2306	65·7	2309	1967	40·9	1872
Protein (g/d)	77·4	2·8	72·8	63·6	1·6	59·0
Carbohydrates (g/d)	357·4	10·1	354·3	312·0	6·3	306·3
Fat (g/d)	69·3	3·2	66·0	57·0	1·8	51·3
Cholesterol (mg/d)	196·3	17·0	140·7	184·1	10·8	111·4
Total SFA (g/d)	16·4	1·0	14·7	14·7	0·5	13·1
Total MUFA (g/d)	26·5	1·4	23·5	22·8	0·9	18·7
Total PUFA (g/d)	20·8	1·2	16·8	15·5	0·6	13·5
Dietary fibre (g/d)	31·3	1·7	26·0	27·1	0·9	24·2
Fe (mg/d)	15·0	0·7	12·1	11·4	0·3	10·4
Ca (mg/d)	401·5	20·3	336·1	397·0	13·6	338·5
Zn (mg/d)	10·5	0·5	9·0	8·3	0·3	7·2
Vitamin C (mg/d)	66·5	4·6	51·2	100·1	4·8	74·2
Vitamin E (mg/d)	7·4	0·4	6·2	6·9	0·2	6·0
Thiamin (mg/d)	1·13	0·05	1·00	0·94	0·03	0·87
Vitamin B_2 (mg/d)	1·38	0·07	1·16	1·20	0·04	1·06
Niacin (mg/d)	19·9	0·9	18·1	15·7	0·5	14·0
Folate (μg/d)	295·9	15·5	266·2	272·0	8·9	236·1
% of total energy						
Protein	13·5	0·3	12·6	13·1	0·2	12·5
Carbohydrate	62·9	0·9	63·9	64·3	0·5	64·4
Total fat	25·9	0·8	25·6	25·1	0·5	24·9

Table 3 Reported energy intake (EI), estimated energy requirement (EER) and ratios of reported EI to estimated BMR and EER among men and women in the Bedouin Nutrition Study

	Men		Women*	
	All (*n* 149)	Usual intake/non-dieters (*n* 111)	All (*n* 138)	Usual intake/non-dieters (*n* 101)
Total reported EI (kcal)†				
Mean	2306	2377	1894	2009
SD	802	829	702	713
FAO estimates and ratios				
EER_{FAO} (kcal)†,‡				
Mean	2797	2754	2204	2210
SD	370	334	215	227
$EI:BMR_{FAO}$	1·32	1·38	1·32	1·40
$EI:EER_{FAO}$	0·83	0·87	0·86	0·91
Oxford estimates and ratios				
EER_{OXF} (kcal)†,§				
Mean	2707	2658	2147	2155
SD	370	359	220	233
$EI:BMR_{OXF}$	1·37	1·43	1·36	1·44
$EI:EER_{OXF}$	0·86	0·90	0·89	0·93

*Pregnant and breast-feeding women were excluded from this analysis.
†To convert to kJ, multiply kcal by 4·184.
‡Calculated using the FAO/WHO/United Nations University equations[24] to obtain BMR, multiplied by physical activity level factor.
§Calculated using the Oxford equations[27] to obtain BMR, multiplied by physical activity level factor.

reported engaging in physically demanding occupations (11%) or household chores (e.g. hand-washing clothes, 6%) daily or in walking/exercise/sports for ≥1 h/d (3%); thus, 84% were classified as having sedentary/light activity, 16% as having moderately active lifestyles and none as having vigorously active lifestyles. We report both the EI:BMR and EI:EER ratios to facilitate comparisons with the results of other studies. The reported EI of the BNS respondents was closer to the EER calculated using the Oxford equations than to that using the FAO/Schofield equations, but with both equations was closer to the EER among respondents who ate the 'usual' amount on the recall day and were not dieting. The FAO/Schofield and Oxford EI:EER ratios were significantly higher among those who reported eating the 'usual' amount (0·88 and 0·91, respectively) than among those who reported eating 'less than usual' (0·70 and 0·72, respectively) on the recall day ($P = 0.001$), and the trend for dieters and non-dieters was similar (data not shown). The mean $EI:EER_{OXF}$ ratios of those with BMI ≥ 26·0 kg/m^2 ($EI:EER_{OXF} = 0·83$) also

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Table 4 Mean and within-person CV of three repeat 24 h recalls for energy and selected nutrients among a subsample of Bedouin Nutrition Study participants

	Men (*n* 15)			Women (*n* 25)		
	Mean	SD	CV (%)	Mean	SD	CV (%)
Energy (kJ/d)	11 133	2761	24·8	9736	2464	25·3
Energy (kcal/d)	2661	660	24·8	2327	589	25·3
Protein (g/d)	86·7	25·2	29·1	72·5	24·5	33·8
Carbohydrates (g/d)	382·6	101·5	26·5	358·0	94·0	26·3
Fat (g/d)	91·2	44·8	49·1	71·3	23·4	32·9
Cholesterol (mg/d)	366·2	229·7	62·7	228·5	192·5	84·3
Total SFA (g/d)	20·9	8·3	39·6	19·0	7·3	38·4
Total MUFA (g/d)	31·6	13·7	43·3	26·2	9·5	36·1
Total PUFA (g/d)	31·9	24·2	75·8	20·7	10·1	49·0
Dietary fibre (g/d)	27·2	8·8	32·2	26·4	8·1	30·8
Ca (mg/d)	425·2	150·8	35·5	478·0	224·8	47·0
Fe (mg/d)	13·4	4·3	31·6	11·8	4·4	37·2
Zn (mg/d)	9·4	2·8	29·6	8·3	3·5	42·2
Vitamin A (IU)	6749	19 297	286	5870	6737	115
Vitamin C (mg/d)	86·8	63·9	73·6	114·0	71·4	62·6
Vitamin E (mg/d)	9·9	6·4	46·4	8·7	5·2	39·9
Thiamin (mg/d)	1·08	0·36	33·4	1·00	0·31	31·3
Vitamin B_2 (mg/d)	1·69	0·81	47·9	1·53	0·92	60·2
Niacin (mg/d)	18·8	7·1	37·8	16·2	6·8	42·2
Folate (μg/d)	337·5	197·9	58·7	332·5	162·2	48·8

differed significantly from those with BMI $< 26{\cdot}0\,kg/m^2$ (EI:$EER_{OXF} = 0{\cdot}90$, $P = 0{\cdot}041$).

The mean intakes of selected nutrients and the within-person CV for three repeat 24 h recalls administered to a subsample of forty respondents are presented in Table 4. The CV for energy and macronutrients ranged from 24·8 % to 49·1 %, those for micronutrients ranged from 31·3 % to 286·0 %.

Discussion

We present a modified USDA 24 h recall questionnaire that quantifies individual intake from common-plate meals among the Negev Bedouin Arab population in southern Israel. Since 88 % of the respondents reported eating common-plate meals on the recall day, we can confirm that common-plate eating is a widespread and enduring practice among Negev Bedouin adults and that an appropriate dietary assessment instrument for common-plate eating is needed. In addition, this population has undergone a major transition from semi-nomadic pastoralists and agriculturalists to sedentarized/urbanized wage labourers, and the transition has been accompanied by dramatically rising rates of chronic diseases[7–10,13,14]. It is reasonable to assume that life changes, including dietary changes, have contributed to increases in chronic disease rates. Thus, an appropriate tool for nutritional surveillance, such as the 24 h recall questionnaire, is crucial for assessing nutrient intake quantity/quality and identifying dietary trends. It will also enable health-care professionals to evaluate the efficacy of interventions targeted at disease prevention and health promotion[11,12].

The dietary assessment tools developed in European-origin cultures are not suitable for measuring individual dietary intake in contexts in which common-plate eating is practised. Alternative methodologies have been developed, ranging from distribution algorithms[3] to observing subjects while eating[2,4]. Generally, these methodologies are quite costly and thus infeasible for large epidemiological studies or ongoing nutritional surveillance, particularly in developing countries where common-plate eating is more likely to be practised.

The modified 24 h recall used among Bedouin adults produced estimates of individual nutrient intakes that were comparable in terms of plausibility of reported EI and day-to-day within-person variation to those of the nutrient intake estimates obtained with the original USDA 24 h recall in other populations. The fact that respondents tend to underestimate their EI with the 24 h recall has been well documented, in both developed[5,28–30] and developing countries/populations[31–33]. We evaluated the plausibility of the reported EI from the modified 24 h recall by comparing it with EER computed using the FAO/WHO/UNU[24] and the Oxford[27] BMR equations. Several of the older equations for calculating BMR (e.g. Harris–Benedict[34]), including the FAO/WHO/UNU equations based on Schofield's BMR data collected in the 1930s[26], have been shown to overestimate energy requirements in modern populations, and particularly those of non-European origin[26,27,35–38]. The Oxford equations were developed more recently using a data set of 10 552 BMR measurements that included a much larger number of non-European subjects[27]. In the present study, the BMR calculated according to the Oxford equations was closer to the EI of the BNS respondents than the BMR calculated

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according to other equations, as well as more sensitive to differences in EI:EER ratios by BMI. The EI:EER and EI:BMR ratios we obtained using both the FAO (Schofield) and Oxford BMR equations were well within the range of EI:EER and EI:BMR ratios reported in the literature for 24 h recall questionnaires[39], particularly when our analysis was limited to non-dieters who ate the usual amount ($EI:EER_{FAO} = 0{\cdot}87$, $0{\cdot}91$; and $EI:EER_{OXF} = 0{\cdot}90$, $0{\cdot}93$; men and women, respectively). A review of studies validating reported energy intake produced a mean EI:EER of 0·87 in studies comparing the reported EI from 24 h recalls with EER measured by doubly labelled water[40]. Among the studies comparing EI from 24 h recalls with estimated BMR, EI:BMR ratios ranged from 1·37 to 1·51 for men and from 1·09 to 1·39 for women. Comparison of reported EI from one 24 h recall in NHANES III with BMR estimated using Schofield's equations resulted in mean EI:BMR ratios of 1·47 and 1·26 for men and women, respectively[5]. In our study, the mean EI:BMR ratios calculated using the FAO/WHO/UNU equations based on Schofield's equations were 1·32 for both men and women. Similar to our findings, Briefel *et al.* reported higher EI:BMR ratios among those who were not dieting, who reported eating the usual amount on the recall day, and who were not overweight[5].

Another characteristic of the 24 h recall and other 1 d dietary records is that they give poor estimates of an individual's habitual diet[41,42], and therefore repeat 24 h recalls from a subsample of respondents have been used to estimate within-person variance in day-to-day dietary intake[43–46]. Based upon a subsample of forty BNS respondents for whom we had three repeat 24 h recalls on non-consecutive days, we computed the within-person variation in day-to-day nutrient intakes. Our results were within the range of the within-person levels of variation from 1 d intake recalls and records found in the published literature[41,43–45,47,48]. Day-to-day variation in intakes are on the level of 25 % or higher for energy and macronutrients[41,43,44,47]. The CV are higher for many micronutrients, particularly those that are found in high amounts in a relatively small number of foods[41,48].

The nutrient intake estimations of the BNS respondents met the criterion for reliable estimates used for nutritional surveillance with the 24 h recall in the NHANES studies. EI in the BNS sample was similar to EI reports for adults based on one 24 h recall in the NHANES data[25,49]; however, the macronutrient distribution differed. BNS respondents obtained a higher proportion of their energy from carbohydrates and lower proportions from protein and fats (63–64 %, 13 % and 25–26 %, respectively) than NHANES respondents (48–50 %, 15–16 % and 34 %, respectively)[50]. When we compared the macronutrient distribution of a subsample of BNS respondents (aged ≥35 years) with that of Jewish Israelis of the same age group, the same trends were found, and the differences were statistically significant[9]. BNS macronutrient intakes showed distributions closer to those reported in middle-income/developing countries (e.g. Iran[51], Korea[52], Chile[53], western Mali[54]) than to those in high-income/developed countries[9,50].

The study has a number of limitations. The BNS sample was not drawn randomly, given the practical, logistical difficulties of randomizing sample selection in this population, so the generalizability of the results is limited. Nevertheless, the sample included a broad geographical cross-section of Negev Bedouin adults from both rural and urban settings among whom the modified 24 h recall was successfully administered, demonstrating the feasibility of using this tool to estimate individual intake from common-plate meals in the Negev Bedouin population. As with the original 24 h recall, the EI:EER ratios below 1·0 obtained with the modified 24 h recall suggest that respondents tend to underestimate EI; and one 24 h recall does not necessarily reflect habitual intake. These factors must always be taken into account when analysing and interpreting short-term dietary intake data. At the same time, the levels of EI underestimation and day-to-day within-person variation in food intake we found with the modified 24 h recall were well within the ranges reported for the original 24 h recall in a variety of other populations.

The modified 24 h recall instrument, which quantifies individual dietary intake from common-plate meals, has the potential to make an important contribution to facilitating large-scale nutritional surveillance in the Negev Bedouin Arab population. Additional dietary studies among the Bedouin are needed in order to further refine and validate the methods of quantifying individual intake from common plates, and future nutritional surveillance studies should include a larger number of repeat 24 h recalls, which would facilitate the estimation of usual nutrient intakes. It may also be possible to adapt the modified 24 h recall to other populations where bread is used for eating from common plates by developing local food:bread ratios. In addition, the model may be useful for developing dietary assessment methods in other common-plate eating contexts by identifying some food/meal component that can be quantified individually and can also be utilized as a vehicle for quantifying the foods eaten from common plates.

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