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Under-reporting of energy and nutrient intake is a persistent issue in the Malaysian Adult Nutrition Surveys

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ABSTRACT

Introduction: Under-reporting of energy intake is a common cause of bias in nutritional studies. This study was aimed at examining the extent of under-reporting of energy intake and its related characteristics among respondents in the Malaysian Adult Nutrition Survey (MANS) 2003 and MANS 2014. **Methods:** The present study analysed energy intakes of 9,624 adults aged 18-59 years from the MANS in year 2014 (2,890 respondents) and 2003 (6,734 respondents) using a single 24-hour diet recall. Basal metabolic rates (BMR) were calculated from the age- and gender-specific equations of Schofield. Under-reporting was defined as an energy intake:BMR ratio of <1.2 as proposed by Goldberg. **Results:** Under-reporting was found to have increased significantly from 53% in 2003 to 61% in 2014. In both surveys, under-reporting increased with higher body mass index (BMI) and older age groups. It was higher among women than men, lowest among those with primary schooling or below, and those living in Peninsular Malaysia. It was higher among rural respondents in 2014 but higher among urban respondents in 2003. The intake of energy and micronutrients increased when under-reporters were excluded. **Conclusion:** Under-reporting was prevalent in both the nationwide MANS, and is associated with BMI, age, gender, education level, location strata, zone. It is important to take this factor into account when assessing dietary intake in population-based studies.

Keywords: Energy intake, 24-hours diet recall, under-reporting, nutrition survey, adults

INTRODUCTION

The under-reporting of energy intake (EI) is a major concern in dietary assessment. Based on the analysis of numerous dietary intake surveys that were conducted among respondents aged 15-84 years old, Black *et al.* (1991) concluded that self-reported EI tends to be under-reported. In addition, more recent studies have pointed out that the under-reporting of EIs resulting from the use of the self-reported method from population nutrition surveys is a considerable problem that has distorted the findings of several surveys. Among these were the United States National

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Health and Nutrition Examination Survey (Briefel *et al.*, 1997), the Canadian Community Health Survey (Garriguet, 2008), the New Zealand Adult Nutrition Survey (Gemming *et al.*, 2014), the Finnish Adults Dietary Survey (Hirvonen *et al.*, 1997), the Korean National Health and Nutrition Examination Survey (Kye *et al.*, 2014), the Australian Children's Survey (Rangan *et al.*, 2011) and the Brazil Nutrition, Physical Activity and Health Survey (Souza *et al.*, 2015). In a French dietary survey using a 7-day food record, 22.5% adults were under-reported (Berta Vanrullen *et al.*, 2014). The extent of under-reporting has ranged from 10-50%.

The validity of the self-reporting of diet histories, food records, 24-hour dietary recalls and food frequency questionnaires (FFQ), are obviously dependent on the degree of accuracy with which the respondents report or recall their food consumption. Several factors appear to be associated with the under-reporting of EIs, including obesity, age, gender, social status, controlled eating habits and the consumption of certain food groups (Azizi, Esmaillzadeh & Mirmiran, 2005; Briefel *et al.*, 1997; Garriguet, 2008; Hirvonen *et al.*, 1997; Johansson *et al.*, 1998; Kye *et al.*, 2014). Specifically, relative to the comparison group, overweight and obese respondents, women and older people were found to under report EI (Briefel *et al.*, 1997; Garriguet, 2008; Hirvonen *et al.*, 1997; Kye *et al.*, 2014). This reporting bias may lead to a misinterpretation of the individual's nutritional state and may also result in misleading associations between diet and disease.

Thus, it is important to assess the extent of under- or over-reporting of EI in nutritional surveys. Most studies, including those cited above, have applied the Goldberg equation (Black, 2000) to distinguish between under-reporting and acceptable reporting. This equation calculates the ratio between EI and basal metabolic rate (BMR). A ratio below 1.2 is considered inadequate for the maintenance of body weight and, thus, identifies the low energy reporters. A further distinction between under-reporting and over-reporting can be made using alternative cut-off points. These cut-off values were obtained by calculating the EI:BMR ratio for each respondent. The cut-off values were then used to identify three ranges: EI:BMR of <1.34 (under-reporting), 1.35–2.39 (normal range) and >2.40 (over-reporting) (Black, 2000).

BMR can be measured based on different equations, e.g. Schofield's equation (Ramirez-Zea, 2005) and Henry's equation (Henry & Rees, 1991; Ramirez-Zea, 2005). In 1985, the Food and Agriculture Organization / World Health Organization/United Nations University (FAO/WHO/UNU) Committee introduced BMR as the basis for calculating the energy requirement for populations aged over ten years old. The FAO/WHO/UNU applied Schofield's equation in computing the BMR of individuals according to age (0-3 years, 3-10 years, 10-18 years, 18-30 years, 30-60 years and >60 years), gender and body weight (WHO, 2001). However, Schofield's predictive equation corroborated mainly with people from Europe and North America and with only 5.2% of those from other parts of the world (Ismail *et al.*, 1998). Another limitation was that the Italian population, who had higher BMR values compared to the other populations, was over-represented in the data (47%) (Ramirez-Zea, 2005).

Henry and Rees (1991) developed a new set of predictive equations to calculate the BMR of people living in tropical countries all over the world. They found that the FAO/WHO/UNU predictive equations had overestimated the BMR of tropical peoples by 8%. Their equation was also tested among the Malays and Chinese populations and pointed to a lower BMR value than that predicted by the FAO/WHO/UNU equation. In other words, it would be more favourable to use the equation developed using the data obtained from our own population rather than the aforementioned predictive equations. Thus, the predictive BMR equation developed by Ismail *et al.* (1998) using data obtained from 656 Malaysian adults (men = 307, women = 349), aged 18-60 years old was used for this study.

The Malaysian Adult Nutrition Survey (MANS) was a series of nationwide surveys to monitor the nutritional status of the Malaysian population. It was carried out first in 2003 and subsequently in 2014. The objectives of MANS were to determine the socio-demography of meal pattern, habitual food intake, dietary intake, vitamin, mineral and food supplement intakes food security, nutritional status and physical activity pattern among Malaysian adults aged 18-59 years old (IPH, 2014c). Mirnalini *et al.* (2008) found that 54.8% of the respondents in MANS 2003 had under-reported their EIs. Despite this being the case, the previous MANS reports (IPH, 2014b; Mirnalini *et al.*, 2008) only published EIs based on total respondents without excluding under- and/ over-reporting.

The present study aimed to examine the level of under-reporting in EIs among Malaysian adults in both MANS 2003 and 2014. It compared the nutrient intakes and other relevant characteristics of those who had under-reported.

MATERIALS AND METHODS

This research was approved by the Ethics Committee of the Ministry of Health Malaysia [NMRR-17-888-34549(IIR)].

Study populations

This study was based on data from two nationwide MANS that were carried out in 2003 and 2014 on a representative sample of Malaysian adults. Briefly, for each survey, a stratified random sample of men and women aged 18-59 years was drawn from the population sampling frame. The sample sizes were 6,887 respondents in 2003 and 2,973 in 2014. Data collection was undertaken covering both weekdays and weekends. All surveys were paper-and-pencil, interviewer-administered and anonymous. Details of the survey methodology for MANS 2003 and MANS 2014 are described elsewhere (IPH, 2014c; Mirnalini *et al.*, 2008). For the present study, respondents with missing data on body weight, 153 in 2003 and 83 respondents in 2014 were excluded. The total number of respondents was, thus, 9,624 (2,890 in MANS 2014 and 6,734 in MANS 2003).

Subject characteristics

The variables analysed in this study were as follows: age classified into four groups (18-29, 30-39, 40-49 or 50-59 years); gender (men or women); education level (primary school, secondary school, and tertiary level being college or university); strata (urban or rural, based on classification of the Department of Statistics Malaysia); zone (resident in Peninsular or East Malaysia); day of dietary recall interview (weekday or weekend), and physical activity (active or not active, based on International Physical Activity Questionnaire). Anthropometric measurements were height in cm measured by a SECA Bodymeter 208 and weight in kg measured by a TANITA 319 weighing scale. Body Mass Index (BMI) was calculated by dividing weight by height in meters squared and classified as normal and underweight (<25.0 kg/m^2), overweight (≥ 25.0 to <30.0 kg/m^2) and obese (≥ 30.0 kg/m^2). Energy and nutrient intake data were obtained from a single 24-hour dietary recall interview. The dietary recall questionnaire was adapted from Gibson and Ferguson (2008). Conversion to nutrients was done using Nutritionist Pro™ Diet Analysis Software (Axxya Systems, 2014).

Cut-off for under-reporting

BMR was calculated based on age- and gender-specific equations proposed by Ismail *et al.* (1998). By definition, The EI was considered under-reported when the EI:BMR ratio was below 1.2. The cut-off that was considered as inadequate for the maintenance of body weight (Goldberg *et al.*, 1991). As the MANS 24-hour dietary recall was designed to estimate short-term habitual intake, the value of 1.2 was selected because it was proposed as the minimum value of habitual EI to fulfil a normal, not bedridden, lifestyle, that can be representative of short-term habitual intake. For the present analysis, respondents were categorised as under-reporters (URs) (<1.2) and non-under-reporters (non-URs) (≥1.2).

Statistical analysis

All statistical analyses were undertaken using the Statistical Package for the Social Sciences (SPSS) version 19.0 (IBM SPSS Statistics, Armonk, NY). The distribution (%) of socio-demographic and health-related variables for URs and non-URs, and summary measures for nutrients were calculated. The statistical significance of differences at $p<0.05$ between the UR and non-UR groups were tested by the chi-square test for categorical variables, and the *t*-test for continuous variables.

RESULTS

The socio-demographic and health characteristics of respondents (URs vs non-URs) for both Surveys are presented in Table 1. Overall, there was a 7.4% increase in the proportion of URs from 2003 compared to 2014, from 53.6% to 61.0%. In both surveys, there were significant differences in the percentages of URs compared to non-URs when the respondents were categorised according to age, gender, education level, strata, zone and BMI. In both MANS 2003 and MANS 2014, the following observations regarding URs were made:

- there was an increasing trend from the youngest age groups (18-29 years old) to the oldest age groups (50-59 years old);
- more among women than men;
- an increasing trend from those with the highest education level (tertiary education) to lowest education level (primary school or less);
- more in urban than rural respondents;
- more in Peninsular Malaysia than East Malaysia; and,
- more among respondents with higher BMI than those respondents with lower BMI.

There were no significant differences in the proportion of URs and non-URs by day of recall, or between active and non-active respondents.

The largest increase in the prevalence of URs from 2003 to 2014 was in the respondents from East Malaysia (13.6%), followed by subjects living in rural areas (12.0%), the age group 30-39 years old, women, respondents with secondary education, those living in Peninsular Malaysia, who offered weekday recall, were physically active and non-active subjects showed higher than the average increase in the proportion of URs. The smallest increase was seen urban respondents (1.3%).

Table 2 shows the results of logistic regression analysis on each socio-demographic characteristic for both surveys. The highest odds ratio was seen among subjects with BMI >30.0 kg/m² who were 4.55 times more likely to under report. Meanwhile, overweight respondents were twice as likely to under-report compared to those with BMI <25.0 kg/m² (the reference group). Similar to the patterns shown in Table 1, the likelihood of under-reporting increased significantly from younger to older age group, in women compared to men. The likelihood of under reporting decreased significantly among those

Table 1. Percentage distribution of URs (<1.2 EI:BMR) and non-URs (≥1.2 EI:BMR) in the Malaysian Adult Nutrition Surveys by sociodemographic and health characteristics

Characteristics	*2003 (n=6734)*			*2014 (n=2890)*		
	URs (n=3609)	*Non URs (n=3125)*	$p^{\dagger}$	*URs (n=1762)*	*Non URs (n=1128)*	$p^{\dagger}$
Overall	53.6	46.4		61.0	39.0	<0.001
Age group						
18-29	47.2	52.8	<0.001	54.3	45.7	<0.001
30-39	52.2	47.8		60.6	39.4	
40-49	60.2	39.8		63.4	36.6	
50-59	62.2	37.8		67.5	32.5	
Gender						
Men	50.1	49.9	<0.001	56.0	44.0	<0.001
Women	57.0	43.0		65.4	34.6	
Education						
Primary or less	60.5	39.5	<0.001	66.0	34.0	0.002
Secondary	51.5	48.5		60.8	39.2	
Tertiary	50.0	50.0		56.9	43.1	
Strata						
Urban	55.7	44.3	<0.001	59.0	41.0	0.019
Rural	51.2	48.8		63.2	36.8	
Zone						
Peninsular Malaysia	56.3	43.7	<0.001	63.6	36.4	<0.001
East Malaysia	43.2	56.8		56.8	43.2	
Days of recall						
Weekdays	52.3	47.7	0.224	62.4	37.6	0.350
Weekends	54.0	46.0		60.5	39.5	
Physical Activity						
Active	53.4	46.6	0.765	60.8	39.2	0.734
Not active	53.8	46.2		61.4	38.6	
BMI						
< 25.0 kg/m^2	44.0	56.0	<0.001	49.1	50.9	<0.001
≥ 25.0 to <30.0 kg/m^2	62.4	37.6		67.0	33.0	
≥ 30.0 kg/m^2	78.1	21.9		81.3	18.7	

† Obtained from chi-square test; Data given as %; UR = under-reporter; Non UR = non-under-reporter

Table 2. Logistic regression analysis of factors predicting under-reporting (<1.2 EI:BMR) status by year in the Malaysian Adult Nutrition Survey

Variable	*2003*		*2014*	
	Odds ratio	*95% CI*†	*Odds ratio*	*95% CI*
Age group				
18-29	1.00		1.00	
30-39	1.22	1.08-1.38	1.29	1.06-1.58
40-49	1.70	1.49-1.93	1.46	1.19-1.79
50-59	1.84	1.57-2.15	1.75	1.40-2.19
Gender				
Men	1.00		1.00	
Women	1.32	1.20-1.45	1.48	1.28-1.72
Education				
Primary	1.00		1.00	
Secondary	0.69	0.62-0.78	0.79	0.66-0.96
Tertiary	0.65	0.56-0.75	0.68	0.55-0.84
Strata				
Urban	1.00		1.00	
Rural	0.83	0.76-0.92	1.19	1.03-1.39
Zone				
Peninsular Malaysia	1.00		1.00	
East Malaysia	0.59	0.52-0.66	0.75	0.64–0.87
Days of recall				
Weekdays	1.00		1.00	
Weekends	1.07	0.96-1.19	0.92	0.77-1.09
Physical Activity				
Active	1.00		1.00	
Not active	1.02	0.92-1.12	1.03	0.88-1.20
BMI				
< 25.0 kg/m^2	1.00		1.00	
≥ 25.0 to <30.0 kg/m^2	2.12	1.89-2.37	2.10	1.77-2.50
≥ 30.0 kg/m^2	4.55	3.83-5.41	4.50	3.54-5.72

† Obtained from logistic regression analysis; data given as CI = confidence interval

with higher education levels compared to those with lower education, and Peninsular Malaysia compared to East Malaysia. However, the likelihood of under-reporting among urban respondents was significantly higher in 2003 but significantly lower in 2014.

The mean energy and micronutrient intakes for 2003 and 2014 are presented in Table 3. The under-reporting of EIs represents the under-reporting of all nutrients that were estimated in MANS. There were significant differences in EIs between URs and non-URs in both 2003 and 2014. In terms of nutrient intake, only the protein intake in 2014 showed no significant difference between URs and non-URs; all other nutrients showed significant differences between UR and non-URs in both 2003 and 2014. If the URs were excluded from the analysis, the mean EIs (for non-URs) in 2003 and 2014 were 2097 (SE±9.3) kcal and 2123 (SE±16.1), respectively.

The data comparing the mean EIs for the total study subjects between 2003 and 2014 is not shown on Table 3. Briefly, the values were 1617 (SE±7.5) kcal in 2003 and 2123 (SE±16.1) kcal in 2014, and they were significantly different (p-value <0.0001).

DISCUSSION

The prevalence of under-reporting in large nutritional surveys ranges from 18-

Table 3. Mean nutrient intake (kcal) for under-reporters (<1.2 EI:BMR) and non-under-reporters (≥1.2 EI:BMR) of energy intake in the Malaysian Adult Nutrition Survey in 2003 and 2014.

MANS (year)	*Variable*	*URs (n=1762) (Mean±SE)*	*Non URs (n=1128) (Mean±SE)*	*p-value*
2003	Energy (kcal)	1203±5	2097±9	<0.001
	Carbohydrate (% energy)	59.6±9.8	56.7±8.9	<0.001
	Protein (% energy)	14.9±4.3	14.7±3.8	0.01
	Fat (% energy)	25.5±8.4	28.6±7.4	<0.001
	Sodium (mg)	1949.0±19.0	3341.0±29.0	<0.001
	Calcium (mg)	305.0±2.9	501.0±4.4	<0.001
	Iron (mg)	7.8±0.1	14.1±0.2	<0.001
	Vitamin C (mg)	51.8±1.1	73.6±1.4	<0.001
	Vitamin A (μg)	395.0±8.7	659.0±12.5	<0.001
	Thiamine (mg)	0.6±0.0	0.9±0.0	<0.001
2014	Energy (kcal)	1198±8	2123±16	<0.001
	Carbohydrate (% energy)	55.7±0.2	53.4±0.3	<0.001
	Protein (% energy)	16.3±0.1	15.9±0.1	0.07
	Fat (% energy)	28.0±0.2	30.7±0.2	<0.001
	Sodium (mg)	1756.0±29.0	3022.0±52.0	<0.001
	Calcium (mg)	339.0±5.3	540.0±9.0	<0.001
	Iron (mg)	12.1±1.3	16.4±0.3	0.008
	Vitamin C (mg)	60.1±2.3	76.9±3.0	<0.001
	Vitamin A (μg)	554.0±20.0	899.0±26.0	<0.001
	Thiamine (mg)	0.6±0.0	0.9±0.1	<0.001

54 percent of the overall sample but can be as high as 70 percent in particular subgroups. This wide variation between studies is partly due to different criteria that were used to identify URs and also because of non-uniformity of under-reporting across populations (Macdiarmid & Blundell, 1998).

The proportion of URs in our study was one of the largest (53.6% in 2003 and 61% in 2014), compared to national surveys elsewhere (Briefel *et al.*, 1997; Garriguet, 2008; Kye *et al.*, 2014; Souza *et al.*, 2015), where the proportion of URs ranged from 9.6% in Canada (Garriguet, 2008) to 50% in Brazil (Souza *et al.*, 2015). All these studies used single 24-hour diet recalls similar to that used in our study. However, most of them used computer-based, interviewer-assisted and/or the multiple pass technique to improve the accuracy of dietary recall (Briefel *et al.*, 1997; Garriguet, 2008; Gemming *et al.*, 2014).

Among the socio-economic and anthropometric variables included in the study, the most notable risk factor was the higher BMI. This study has revealed that overweight and obese respondents were two and four times more likely to under-report, respectively, compared to respondents with normal BMI. This finding is similar to that of other studies where there was an inverse association between BMI and self-reporting of EI (Kye *et al.*, 2014; Macdiarmid & Blundell, 1998; Orcholski *et al.*, 2015; Souza *et al.*, 2015).

In both MANS surveys, more women were found to under-report EI than men. Macdiarmid and Blundell (1998) revealed that in 11 of the 12 studies that they reviewed, women were significantly more likely to under-report their dietary intake than men. In the United States, 28% women were URs compared to 18% in men (Briefel *et al.*, 1997), while in New Zealand 25% of the women were URs compared to 21% in men (Gemming *et al.*, 2014). The same trend was also be seen in South Korea, where 23.0% women were URs compared to just 14.4% in men (Kye *et al.*, 2014). It is believed that women tend to be more concerned about their body weight, food, and eating than men (Macdiarmid & Blundell, 1998) and they perceive under-reporting to be a socially acceptable behaviour (Schoeller, 1990) in order to conform to a healthy diet.

Our study has identified age as a strong independent predictor of under-reporting. Older respondents group (50-59 years old) under-reported EI more than younger respondents group (18-29 years old). The true impact of this relationship is unknown as age tended to be associated with other characteristics such as BMI (Macdiarmid & Blundell, 1998).

Our results have also identified educational level as a strong independent predictor of under-reporting. Under-reporting is more common among respondents with lower educational background (primary school or less). Generally, other studies have also found under-reporting to be associated with lower educational levels (Briefel *et al.*, 1997; Klesges, *et al.*, 1995; Kye *et al.*, 2014). This finding is not surprising as most methods for recording food intake depend heavily on literacy. In contrast to this study, Hirvonen *et al.* (1997) found that under-reporting was associated with high level of education among Finnish adults. While Azizi *et al.* (2005) found educational level of under-reporters did not differ significantly among Iranians adults.

No relationship was found between self-reported physical activity and under-reporting of EI. Self-reporting of physical activity is probably subject to similar error to those in reporting food intake, but BMR is unlikely to explain the lower EIs reported by under-reporters (Bedard, Shatenstein & Nadon, 2004).

The inclusion of weekends is expected to raise EIs since it has been shown that food intakes were higher during the weekends compared to weekdays (Macdiarmid & Blundell, 1997). However, our study could find no significant relationships between food intakes during weekends and weekdays.

Both surveys showed higher under-reporting in Peninsular Malaysia than in East Malaysia. This was due to higher prevalence of obesity in the former (Azmi *et al.,* 2009; IPH, 2014b).

The only discrepancy between MANS 2003 and MANS 2014 involved the proportion of under-reporting among urban respondents. MANS 2003 showed a higher proportion of under-reporting among urban respondents in 2003 compared to 2014, whereas MANS 2014 shows the opposite. These differences cannot be explained by BMI of the urban and rural respondents as there were no significant differences between them in both surveys (Azmi *et al.*, 2009; Institute for Public Health, 2014b).

Finally, our study showed a significant increase in energy and micronutrient intakes when URs were excluded. The previous findings before removing the mis-reporting showed a median EI of 1,540 kcal in MANS 2003 (Mirnalini *et al.*, 2008) decreasing to 1,466 kcal in MANS 2014 (IPH, 2014a) which contradicted the increasing obesity in the Malaysian population over that period. In fact, the intake of all micronutrients was reported to have decreased from 2003 to 2014 to below the Malaysian Recommended Nutrient Intake (IPH, 2014a; Mirnalini *et al.*, 2008). Based on our findings, it is clear that the effects of the under-reporting EI will carry over to almost all other nutrients, that is, the under-reporting of EI will indirectly affect the under-reporting of other nutrients. This important conclusion opens the door to better assessments and interpretations of self-reported dietary intake. It also provides the reason for future researchers to develop strategies to minimize inaccuracies.

The EI:BMR ratios used as cut-off points also vary between studies. This study defined a ratio of 1.2 as the minimum ratio for the maintenance of body weight, which is in accordance with previous studies conducted in Malaysia (Lee, Norimah & Ismail, 2010; Mirnalini *et al.*, 2008; Sahathevan *et al.*, 2015; Sharif, Wen & Rajikan, 2016). For instance, the second National Health and Nutrition Examination Survey (NHANES II), a national survey that used 24-hour diet recall, had also utilised the same cut-off point of 1.2 (Klesges, Eck & Ray, 1995). There are other studies that have used the same cut-off points of <1.2 to identify under-reporting among Asian populations, such as Southern Indian (Sudha *et al.*, 2006) and Malaysian populations (Lee *et al.*, 2010; Mirnalini *et al.*, 2008; Sahathevan *et al.*, 2015; Sharif *et al.*, 2016).

The magnitude of misreporting in EI varies according to the choice of cut-off points and the methodologies used in the collection of dietary data (Goldberg *et al.*, 1991; Johansson *et al.*, 1998). The cut-off point that was used in this study (<1.2) would have resulted in a higher percentage of under-reporting compared to other cut-off point choices. In addition, the use of a 24-hour diet recall could result in a lower EI:BMR ratio compared to other methods (Goldberg *et al.*, 1991). This is a possible explanation for this study's findings, in which there is a high prevalence of under-reporting of EIs. Without technological innovation, the under-reporting of EIs will remain a major limitation of the 24-hour dietary recall method used in large-scale nutrition surveys (Gemming *et al.*, 2014).

Gender differences have been shown to be important in under-reporting. In the Canadian study, 54% men compared with 35% women were URs; the disparity may be due to the fact that EI was estimated using food frequency questionnaires (Bedard *et al.*, 2004). In a survey in Finland, 46% of women and 42% of men were URs based on three-day food record method (Hirvonen *et al.*, 1997).

Inaccuracies and unreliability in self-reporting are features in which human beings monitor various aspects of their own behaviour or the impact of their behaviour on themselves or the environment. Often, there is no way of checking the validity of self-reporting. However, in nutrition, the use of formulations based on biological processes such as EI:BMR for example, provide a guide to the reliability of the self-reporting (Macdiarmid & Blundell, 1997). The strength of this study was the use of EI:BMR ratio as it provided a reasonable guide to check the validity of self-reported dietary intake. The limitation of this study, however, was the use of a single 24-hour diet recall that was not able to capture the usual day to day variability in food intake. It is suggested that future studies should use a computer-based interviewer-assisted method of 24-hour dietary recall using multiple pass technique.

This study will should provide the basis in the analysis of nutrient intake for any future MANS that may be undertaken. It would do so by taking under-reporting into account in order to derive more accurate data on nutritional intake.

CONCLUSION

This study has shown that under-reporting of EI increased from the MANS 2003 to the MANS 2014 in Malaysian adults. There was under-reporting in almost all major nutrients. The magnitude of under-reporting tends to distort the relationship between EI and obesity. Under-reporting was more evident in higher BMI, women, older adults, those who had a lower education level, and living in Peninsular Malaysia. Therefore, URs must be taken into account when assessing dietary intake in population-based studies, and efforts made to reduce its occurrence in the sub-groups identified at higher risk, especially those with high BMI. The accuracy of dietary intake assessment can be improved with better techniques.

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Author's contributions

AAZ, wrote the manuscript with support and supervised from all authors. AINI and SMY, verified the analytical methods. All authors provided critical feedback, discussed the results and contributed to the final manuscript.

Conflict of interest

The authors declare that there is no conflict of interest.

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