Original Article

Correlates of under- and over-reporting of energy intake in Tehranians: body mass index and lifestyle-related factors

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Under- and over-reporting of energy intake are problems in dietary intake assessment. This study was conducted to assess the correlates of under- and over-reporting of energy intake in Tehranians. Dietary data on 947 participants (415 males and 532 females) of the Tehran Lipid and Glucose Study was collected by trained interviewers using two 24-hour recalls. Weight and height were measured by digital scale and tape measure according to standard protocols and recorded to the nearest 100g and 1cm, respectively. Under-, normal- and over-reporting of energy intake was defined as ratio of energy intake to basal metabolic rate (EI: BMR) <1.35, 1.35 - 2.39 and ≥ 2.4, respectively. Mean ± SD of age was 37.3 ± 14.6 and 32.9 ± 13.6 years for men and women, respectively. Men had higher EI: BMR than women (1.72 ± 0.44 vs 1.27 ± 0.44, P<0.001). EI and EI: BMR was highest in the youngest age groups in both sexes. The prevalences of under- and over-reporting were 31% and 5%, respectively. Fewer men than women underreported EI (19% vs 40%, P<0.001). The fraction of over-reporters was significantly higher in men than women (7% vs 3%, P <0.05). EI: BMR decreased with age. Under-reporters were older and had higher BMI than normal-reporters, but their educational level did not differ significantly. Over-reporters were younger and had lower BMI than normal-reporters, but their educational levels did not differ significantly. Most over-reporters had normal BMI. Smoking was more prevalent in over-reporters than in the normal-reporters (28% vs 19% in men and 6% vs 1% in women, P<0.01). The results showed a high prevalence of misreporting of energy intake in Tehran. This phenomenon is related to age, obesity and smoking habits.

Key Words: under-reporting, over-reporting, BMI, lifestyle, Tehran Lipid and Glucose Study, Iran

Introduction

Research on the association between diet and the aetiology of chronic disease has proven to be one of the most challenging areas of nutritional epidemiology. It is widely recognized that one of the main causes of uncertainty regarding the role of diet in the aetiology of chronic disease is the intrinsic lack of accuracy of dietary intake assessment methods.[1] In the last two decades there has been a growing awareness of the sources of bias in any measure of diet. Under- and over-reporting of energy intake in comparison to energy expenditure is one of these factors. Doubly Labeled Water (DLW) can be used as an accurate method for determining energy expenditure, but because of the high cost and complexity involved in the use of this technique in large epidemiologic studies, researchers prefer to use the ratio of energy intake to basal metabolic rate (EI: BMR) for detecting under- and over-reporting of energy intake.[2-5] Most of these studies suggest the high prevalence of underreporting,[2,3] however, a few investigations have addressed the issue of over-reporting of dietary intake and the percentage of subjects over-reporting their energy intake was found to be below 9%.[3,6]

Several studies have assessed factors associated to under- and over-reporting of energy intake but with inconsistent results. Some studies suggest a direct correlation of obesity indicators to under-reporting[3-5,7] and an indirect one to over-reporting[3,8] but other researchers failed to achieve these results[9,10] or achieved it only in women.[11] While most scientists reported higher prevalence of under-reporting among women than in men,[3,12] some gathered contrary evidence[5] and yet others observed no difference between sexes.[4,8] Lifestyle-related factors, also, have been assessed to be contributing factor in under- and over-reporting. Some investigations showed a direct correlation of smoking to underreporting[7] and some to over-reporting.[3,8] Educational level has been found to be inversely related to underreporting[5,12] but the other studies report either a positive (in men)[8] or no association.[13] On the other hand, almost all of the data that address the issue of under-reporting of food intake come from affluent societies and little data exists in developing countries.

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Therefore this study was designed to determine the correlates of under- and over-reporting of energy intake in Tehranians.

Materials and methods

This cross-sectional study was conducted within the framework of the Tehran Lipid and Glucose Study (TLGS), a prospective study performed on residents of district-13 of Tehran with the aim of determining the prevalence of non-communicable disease risk factors and developing a healthy lifestyle to curtail these risk factors.[14] In the TLGS, 15005 people aged 3 years and over, living in district-13 of Tehran, were selected by multistage cluster random sampling method. A subsidiary population aged 16-80 years old consisting of 947 subjects (415 males and 532 females) were selected randomly for dietary assessment. It should be kept in mind that this sample also includes those who were on a weight-reducing diet. The proposal of this study was approved by the research council of Endocrine Research Center of Shaheed Beheshti University of Medical Sciences and informed written consent was obtained from each subject.

Data collection

Subjects were interviewed privately, face-to-face. Interviews were conducted by trained dietitians using a pre-tested questionnaire. Initially information on socio-demographics including age, educational level and smoking habits was collected. Anthropometric measurements of weight and height were determined using a digital electronic weighing scale and tape meter while the subjects were lightly clothed and wearing no shoes or restrictive underwear.[15] Weight was recorded to 100g and height to the nearest 1cm. All measurements were made by the same individual to eliminate subjective error and maintain uniformity. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Subjects were divided to subgroups according to their BMI: Underweight (<18.5), normal-weight (18.5-24.9), overweight (25-29.9) and obese (≥30).

Trained nutritionists, who had at least 5 years of experience in the Nationwide Household Food Consumption Survey Project, collected dietary data using two quantitative 24-hour dietary recalls. The first recall was completed at the subject's home and the second at the TLGS Research Unit within 3 days after the first one by the same interviewer. Subjects were asked to recall all foods and beverages consumed during the preceding 24-hours. To assist subjects to recall accurately, household utensils were used. Mothers were asked about the type and quantity of meals and snacks when subjects were unable to recall. Food values were usually recorded as household measures in details. Portion sizes of consumed foods were converted to grams using household measures.[16] Each food and beverage was then coded according to the prescribed protocol and analyzed for content of energy and the other nutrients using the Nutritionist III software program modified for Iranian foods. The Basal Metabolic Rate (BMR) was calculated based on weight, age and sex according to Schofield's equations.[17]

Goldberg *et al.*,[18] calculated the minimum requirement of energy based on measuring of total energy expenditure by whole-body calorimetry and coefficients for physical activity levels suggested by FAO/WHO/UNU.[17] They found that an EI:BMR <1.35 was not consistent with usual dietary intake. So we defined under-reporting of energy intake as EI:BMR <1.35. Over-reporting of energy intake was defined as EI:BMR ≥2.4 as suggested by Black *et al.*[19] A range of 1.35-2.39 was considered as normal-reporting of dietary intake. Educational levels of subjects were scored as follows: illiterate = 0, persons able to read and write = 2, elementary school = 5, guidance school = 9, high school graduate = 12, intermediate = 14, bachelors = 16, masters and GP = 18 and specialist = 20. Subjects were divided into low (score <5), moderate (6-12), or high-educated (>12) persons based on educational level score. Subjects were divided into one of the following subgroups according to their smoking habits: daily smokers, ex-smokers, occasional smokers and nonsmokers.

Statistical methods

Findings are shown as mean ± SD and in some cases as the percentage of subjects. Student's t test was used to detect any differences between characteristics of men and women. One-way analysis of variance (ANOVA) with the correction of Bonferroni was used for comparing means. Chi-square test was applied for detecting differences in proportions. *P* value was considered significant at <0.05. All statistical analysis was conducted using SPSS (SPSS, Inc. Chicago, IL: Version 9.05) for windows.

Results

There were 133 men and 247 women aged 16-29 years, 195 men and 209 women aged 30-49 years, 87 men and 76 women aged 50 and over in this study. Table 1 shows background variables, anthropometric data, energy intake and lifestyle factors.

Men had higher ages and EI: BMR than women (1.72 ± 0.44 vs 1.27 ± 0.44, $P<0.001$). Although men consumed more energy than women (2864 ± 752 vs 2066 ± 608 Kcal/d), their BMI was significantly lower than that of women (24.8 ± 4.4 vs 25.9 ± 5.4 Kg/m^2, $P<0.001$). BMI was inversely related to EI: BMR in both men and women ($r = -0.25$, $P<0.01$ and $r = -0.29$, $P<0.01$, respectively). Men were more educated than women (8.5 ± 4.1 vs 7.9 ± 3.6, $P<0.05$). Although fewer men, than women, under-reported their energy intake (19% vs 40%, $P<0.01$), over-reporting was more prevalent in men than women (7% vs 3%, $P<0.05$). The proportion of obesity was lower in men than in women (12% vs 23%, $P<0.01$). Among men daily smokers had a higher, and nonsmokers a lower prevalence than women (19% vs 1%, $P<0.01$ and 68.5% vs 98.3%, $P<0.01$ respectively). More men than women had higher levels of education (13% vs. 7%).

Energy intake was highest in the youngest age groups of both sexes (Tables 2 and 3). The 16-19 year age group had the highest EI: BMR, that was significantly different from all age groups in men whereas in women it differed

Table 1. Energy intake, anthropometry and lifestyle-related variables in men and women

Variable	Men $N = 415$	Women $N = 532$
Age (years)	37.3 ± 14.6	32.9 ± 13.6*
Energy intake (Kcal/d)	2864 ± 752	2066 ± 608*
BMR (Kcal/d)	1668 ± 204	1410 ± 123*
Height (cm)	171 ± 6	158 ± 6*
Weight (Kg)	72.6 ± 13.1	64.5 ± 13.2*
BMI (kg/m^2)		
Mean ± SD	24.8 ± 4.4	25.9 ± 5.4*
*Distribution (%)***		
<18.5	8	6.5
18.5-24.9	46.5	40.5
25-29.9	33.5	30
≥30	12	23
EI: BMR		
Mean ± SD	1.72 ± 0.44	1.27 ± 0.44*
*Distribution (%)***		
<1.35	19	40
1.35-2.3	74	57
≥ 2.4	7	3
Score of education‡		
Mean ± SD	8.5 ± 4.1	7.9 ± 3.6†
*Distribution (%)***		
≤5	23	26
5-12	64	67
>12	13	7
Smoking habits ** (%)		
daily	19	1
occasional	1.5	0.5
ex-smoker	11	0.2
non-smoker	68.5	98.3

* P<0.001, †P<0.05 compared to men; ** Significantly different between sexes; P<0.001; ‡ Based on scoring mentioned in methods

significantly from the 3 age groups over 40. Reduction of EI: BMR with age in women was more than in men. Underreporting of energy intake increased with age. BMI increased with age up to 50 years in men and to over 60 years in women. As age increased, the proportion of subjects with less education rose and that of the moderately-educated decreased. Smoking was more prevalent in men up to 40 years after which its proportion decreased. As presented in Table 4, underreporters were older (41.2 ± 13.9 vs 37.1 ± 14.6 years in men and 37.6 ± 13.8 vs 32.2 ± 13.6 years in women) and had higher BMI (26.7 ± 4.5 vs 24.5 ± 4.3Kg/m^2 in men and 27.7 ± 5.4 vs 24.9 ± 5.1 Kg/m^2 in women) than normal ones. Scores of education in under-reporters men and women did not differ significantly from normal-reporters. Underreporting increased with BMI so that most male underreporters were overweight and most female underreporters were overweight and obese. Among the males fewer under-reporters were smokers as compared to normal-reporters (9% vs 19%, P<0.05). None of the female under-reporters were daily smokers and only 1% smoked occasionally. Percent of subjects with low-, moderate- and high-education did not differ between male and female under-reporters with their normal-reporter counterparts.

Over-reporters were younger (34.5 ± 15.9 vs 37.1 ± 14.6 years in men and 24.6 ± 8.3 vs 32.2 ± 13.6 years in women) and had lower BMI than normal-reporters (22.7 ± 2.9 vs 24.5 ± 4.3 Kg/m^2 in males and 22.1 ± 4.2 vs 24.9 ± 5.1 Kg/m^2 in females). Overreporters' scores of education had no significant difference with those of normal-reporters, but female over-reporters had higher levels of education than did under-reporters. Most male and female over-reporters had normal BMI. Smoking was more prevalent in over-reporters than under-reporters (28% vs 19% in males, P <0.01 and 6% vs 1%, P <0.01 in females). Fewer percent of female over-reporters, in comparison with normal-reporters, had low-education levels but the proportion of females with moderate-education was higher in over-reporters than normal-reporters (82% vs 67%, P <0.05). The proportion of male over-reporters with high-education was lower than normal ones (3% vs 14%, P <0.05).

Discussion

This study, conducted on an urban population of Tehran, revealed that misreporting of energy intake is a prevalent phenomenon in our country. Underreporters had higher age and BMI, and over-reporters had lower age and BMI, than did normal-reporters. Under-reporting was more prevalent in females than in males. There were no significant differences between educational levels with under- and over-reporting subjects, but a positive relationship was observed between smoking and over-reporting.

The present study, as did NHANES II,[20] applied 24-hour dietary recalls for dietary assessment with a view to collecting more detailed data for research purposes. The other studies used a diet record[4] and food frequency questionnaire[3] for collecting dietary data. As previous studies showed misreporting of energy intake is different between methods used to collect dietary data[3,18] and using 24-hour recall could result to the lowest EI: BMR ratio compared to other methods.[18] This is the possible reason for the high prevalence of misreporting of energy intake in the present study. The difference between methods used in various studies and their validity and reliability can explain, to some extent, the difference in findings of these studies. In this study we used EI: BMR, recommended by Goldberg *et al.*,[18] for identifying under-reporters. According to cut-off point of 1.35, the prevalence of under-reporting in males and females in our study were 19% and 40%, respectively. Also, the rates of over-reporting, by the cut-off point of an EI: BMR ≥2.4 suggested by Black *et al.*,[19] were 3% and 7% for females and males, respectively. Other investigations, also, used an EI: BMR ratio.[2,3,13,22-24] Lafay *et al.*,[2] chose a cut-off point of <1.05 and reported the same prevalence of under-reporting for men and women (16%). Voss *et al.*,[13] applied the same cut-off point as our study and found 40% of under-reporting. The proportions of male and female under-reporters in our study were found to be lower than those estimated in British,[21] Finnish[22] and Swedish[23] studies and higher than American[12] and Australian[24] ones. Different equations for BMR and different cut-points to identify under-reporters could lead to different findings by investigators.

Means of EI: BMR in the present study was 1.72 and 1.27 for males and females, respectively and the mean EI: BMR for females in our sample is well below the cut-off

Table 2. Energy intake, anthropometry and lifestyle-related variables in various age groups in men.

Variable	Age (years)					
	16-19 (*N* = 68)	20-29 (*N* = 65)	30-39 (*N* = 87)	40-49 (*N* = 108)	50-59 (*N* = 56)	≥ 60 (*N* = 31)
Energy (Kcal/d)	3034 ± 765*	3002 ± 920*	3041 ± 716*	2777 ± 628	2666 ± 639	2364 ± 752
BMR (Kcal/d)	1676 ± 181*	1783 ± 240‡	1742 ± 167‡	1664 ± 172	1532 ± 142	1465 ± 177
EI: BMR	1.91 ± 0.42**	1.69 ± 0.51	1.76 ± 0.45	1.68 ± 0.39	1.74 ± 0.41	1.62 ± 0.51
Weight (Kg)	63 ± 12**	73 ± 17	76 ± 11	76 ± 11	72 ± 10	73 ± 11
Height (cm)	173 ± 6**	175 ± 6	172 ± 6	170 ± 6	168 ± 6	168 ± 6
BMI (Kg/m^2)	21.0 ± 3.6	23.8 ± 5.6**	25.9 ± 3.7	26.2 ± 3.6	25.7 ± 3.6	25.7 ± 3.4
Score of education	2.28 ± 0.54	2.18 ± 1.01	2.36 ± 1.01	2.22 ± 0.82	2.16 ± 1.16	1.87 ± 0.99**
EI: BMR† (%)						
<1.35	10	23	15	23	26	26
1.35-2.39	81	68	76	74	69	64
≥ 2.4	9	9	9	3	5	10
BMI† (%)						
<18.5	34	9	1	2	-	-
18.5-24.9	51	59	46	36	45	55
25-29.9	13	19	38	46	41	39
≥ 30	2	13	15	16	14	6
Smoking habits (%)						
Daily	2	10	36	23	18	16
Occasional	3	2	1	1	1	-
Ex-smoker	0	4	9	17	20	18
Non smoker	95	84	54	59	61	66
Score of education†(%) ***						
≤ 5	3	12	14	25	48	61
6-12	97	74	67	59	32	32
>12	0	14	19	16	20	7

*Significantly different from age group>50 years ; ** Significantly different from all age groups (ANOVA with the correction of Bonferroni, *P*<0.001); † Significant difference among age groups (Chi-square, *P*<0.05); ‡ Significantly different from age group >40 (ANOVA with the correction of Bonferroni, *P*<0.05); *** Calculated based on scoring mentioned in methods.

Table 3. Energy intake, anthropometry and lifestyle-related variables in various age groups in women

Variable	Age (years)					
	16-19 *N* = 116	20-29 *N* =131	30-39 *N* =120	40-49 *N* = 89	50-59 *N* = 55	> 60 *N* = 21
Energy (Kcal/d)	2223 ± 613†	2109 ± 604*	2124 ± 614*	2069 ± 645	1854 ± 500	1682 ± 447
BMR (Kcal/d)	1424 ± 103*	1411 ± 115*	1422 ± 117*	1433 ± 155*	1349 ± 111	1313 ± 97
EI: BMR	1.79 ± 0.43‡	1.5 ± 0.45*	1.5 ± 0.47*	1.45 ± 0.45	1.37 ± 0.37	1.28 ± 0.32
Weight (Kg)	58 ± 10**	60 ± 12**	67 ± 12	73 ± 15	69 ± 10	71 ± 9
Height (cm)	161 ± 6*	160 ± 6*	158 ± 5	156 ± 6	154 ± 6	152 ± 4
BMI (Kg/m^2)	22.5 ± 4**	23.3 ± 4.5**	26.9 ± 4.7†	29.7 ± 5.6	29.0 ± 3.7	30.7 ± 3.8
Score of education	2.25 ± 0.43	2.26 ± 0.87	2.27 ± 0.77	2.02 ± 87	1.80 ± 0.89	0.76 ± 1.04‡
EI: BMR*** (%)						
<1.35	34	35	42	46	49	43
1.35-2.39	62	59	56	53	51	57
≥2.4	4	6	2	1	0	0
BMI*** (%)						
<18.5	12	13	3	0	0	0
18.5-25	63	58	31	18	18	10
25-29.9	22	20	41	33	39	37
≥30	3	9	25	49	43	53
Smoking habits (%)						
Daily	0	0	2	1	2	0
Occasional	1	0	0	1	0	0
Ex-smoker	0	0	0	1	0	0
Non smoker	99	100	98	97	98	100
Score of education*** (%) ‡						
≤5	1	6	18	52	76	95
6-12	99	79	74	42	20	5
>12	0	15	8	6	4	0

*Significantly different from age group>30 years *P*<0.01; ** Significantly different from all age groups *P*<0.001; *** Significant difference among age groups; *P*<0.05 † Significant difference from age groups >40; *P*<0.05 ‡Calculated based on scoring mentioned in methods

Table 4. Body mass index and lifestyle related variables in relation to EI: BMR

Variable	EI: BMR (men)			EI: BMR (women)		
	<1.35	1.35-2.39	≥2.4	<1.35	1.35-2.39	≥2.4
Age (years)	41.2 ± 13.9**	37.1 ± 14.6	34.5 ± 15.9*	37.6 ± 13.8**	32.2 ± 13.6	24.6 ± 8.3**
Weight (Kg)	78.8 ± 13.0**	71.7 ± 13.0	66.1 ± 8.3**	68.6 ± 13.6*	62.1 ± 12.2	56.7 ± 10.6**
Height (cm)	172 ± 6	171 ± 6	171 ± 6	157 ± 6	158 ± 6	160 ± 4
BMI (Kg/m^2)	26.7 ± 4.5**	24.5 ± 4.3	22.7 ± 2.9**	27.7 ± 5.4**	24.9 ± 5.1	22.1 ± 4.2**
Energy (Kcal/d)	2037 ± 386**	2924 ± 529	4418 ± 676**	1523 ± 323**	2361 ± 387	3578 ± 290**
Score of education	8.7 ± 3.9	8.5 ± 4.2	8.0 ± 3.0	7.6 ± 3.7	8.0 ± 3.6	8.6 ± 2.9
BMI*** (%)						
<18.5	4	9	7	3	7	24
18.5-24.9	32	48	75	31	46	53
25-29.9	37	34	14	33	28	23
≥30	27	9	4	33	19	0
Smoking habits *** (%)						
daily	9	19	28	0	1	6
occasional	4	1	2	1	0.5	0
ex-smoker	15	11	7	0	0.5	0
Nonsmoker	72	69	63	99	98	94
Score of education*** (%)‡						
≤5	17	24	28	28	26	6
6-12	69	62	69	66	67	82
>12	14	14	3	6	7	12

*P<0.05 and ** P<0.01, compared to EI: BMR=1.35-2.39 ***; Significant difference among groups, P<0.05;
‡Calculated based on scoring mentioned in methods

for under-reporting and markedly different from the men. Although the reason for this finding is unclear, it is possible that many of women in this sample had male spouses who were the primary food preparers in the household. The other possible reason for this finding is the oversight in omission of subjects with weight-reducing diets. Since women were more sensitive to their appearance and fitness than men, their EI: BMR and under-reporting rate would be higher than the men. These figures were higher than those suggested by WHO[17] for men (1.55) and lower for women (1.56), but were the same as those reported by Briefel *et al.*,[12] for women and higher for the men in this study. In the present study, consistent with some studies[3,20] and contradictory to others,[2,25] under-reporting was more prevalent in women than men. The difference observed among studies with regard to the prevalence rate of under-and over-reporting and sex differences in its prevalence can be explained by the different cut-off points used in studies, lack of uniformity in dietary assessing methods, nonconformity in the age groups studied and lack of homogeneity in cultural, racial and psychological factors among communities. The high prevalence of under-reporting in the present study can be attributed to the oversight in omission of subjects with weight-reducing diets. On the other hand, since women were more sensitive to their appearance and fitness than men, their underreporting rate would be higher than were men. More men over-reported their intake than women. This finding is consistent with results achieved by DLW studies[26] and contradictory to that of Johansson *et al.*,[3] based on the same cut-off point as our study. Higher over-reporting rate of men may be attributed to the inaccurate estimation of portion sizes of eaten foods due to an inadequate knowledge about preparation methods.

In the present study under-reporting was positively and over-reporting negatively related to age and BMI, respectively. Other studies, also, suggest the correlation of under-reporting to obesity,[13,20] so that an increase in BMI of one unit was related to a 16% increase in under-reporting.[20] Such findings have also been seen in studies where weight and height were self-reported.[2] Under-reporting was not confined to obese people and several studies indicated that normal-weight people, also, under-report their intake and some studies reported that BMI accounted for only 6% of changes in underreporting.[6] So, it seems that factors other than obesity, also, are important in under-reporting but most researchers are in agreement that EI: BMR decrease with BMI or adiposity.

Consistent with our findings, increasing age was correlated to decreasing of EI:BMR in other investigations as well.[2,3,12] Klesges *et al.*,[20] however, reported a higher prevalence of under-reporting in younger women than in older ones. This finding may be explained by inaccurate dietary data in their study, since a 1-day dietary recall was used for data collecting and considering the fact that the diet of younger people varies more than that of older persons from day to day, these data are inadequate in demonstrating the usual dietary intake of young persons. We found no significant relationship between educational level and under- or over-reporting. This is in agreement with Voss *et al.*,[13] Klesges *et al.*,[20] reported a 6% reduction in under-reporting with each four-year increment in educational level. Other researchers, also, observed an inverse correlation of education to under-reporting.[27] Differences in the scoring methods of education and varying attitudes of individuals to food or obesity in different countries could explain, to some extent, these heterogeneities in findings.

Smoking was related to increases of EI: BMR in this study. Johansson *et al.*,[3] also reported this, but other investigators failed to demonstrate this.[7] We should keep in mind that using the same equations in smokers and nonsmokers for calculating of BMR and energy requirements can lead to under-estimation of the under-reporting rate in smokers, because of the higher BMR of smokers than nonsmokers.[12]

In conclusion, misreporting of energy intake using recall methodologies is a common problem in Tehranians. Factors such as age, sex, obesity and smoking are correlated to this phenomenon. Hence, it is recommended this problem be kept in mind in analyzing dietary data and interpreting the relation of diet to health. This problem was overlooked in studies previously conducted in Iran and the findings of such studies could be biased. We suggest, also, that future studies evaluate the effect of misreporting of energy intake on the consumption of nutrients and try to answer this question: Which nutrients are affected by misreporting of energy intake?

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