Biol Trace Elem Res
DOI 10.1007/s12011-017-0972-8

Dietary Intake of Minerals, Vitamins, and Trace Elements Among Geriatric Population in India

Aakriti Gupta[1] · Preetika Khenduja[1] · Ravindra Mohan Pandey[2] · Hem Chandra Sati[2] · Nighat Yaseen Sofi[1] · Umesh Kapil[1]

Received: 29 November 2016 / Accepted: 14 February 2017

Abstract The geriatric population is at a high risk of developing deficiencies of essential micronutrients such as minerals, vitamins, and trace elements and their related deficiency signs and symptoms. Scarce data is available on the dietary intake of essential micronutrients among geriatric subjects in India. Hence, to fill the gap in the existing knowledge, a community-based cross-sectional study was conducted during 2015–2016 in District Nainital, Uttarakhand State, India. A total of 255 geriatric subjects were enrolled from 30 clusters (villages) identified by using population proportionate to size sampling methodology. Data were collected on sociodemographic profile and dietary intake of essential micronutrients (24-h dietary recall, food frequency questionnaire) from all the geriatric subjects. A high percentage of geriatric subjects did not consume the recommended daily intake for essential micronutrients such as energy (78%), protein (78%), calcium (51%), thiamine (33%), riboflavin (64%), niacin (88%), vitamin C (42%), iron (72%), folic acid (72%), magnesium (48%), zinc (98%), copper (81%) and chromium (89%) adequately. Food groups rich in essential micronutrients such as pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, nonvegetarian food items, and milk and milk products were consumed irregularly by the subjects. The overall intake of energy and essential micronutrients was inadequate among the geriatric population in India, possibly due to poor quality and quantity of the diet consumed.

Keywords Dietary intake · Minerals · Vitamins · Trace elements · Geriatric · Elderly

✉ Umesh Kapil
umeshkapil@gmail.com

1 Department of Human Nutrition, All India Institute of Medical Sciences, New Delhi, India

2 Department of Biostatistics, All India Institute of Medical Sciences, New Delhi, India

Introduction

Essential micronutrients such as minerals, vitamins, and trace elements, although needed in minute quantities, play an important role in maintaining functioning, growth, and development in humans. The deficiency or excess of essential micronutrients may severely affect metabolic and physiologic processes [1, 2].

Scientific evidence suggests that the geriatric population is at a high risk of developing deficiencies of essential micronutrients such as calcium, zinc, iron, folic acid, copper, vitamin B_{12}, and vitamin D [3, 4]. This is possibly due to the decline in the quality and quantity of overall food intake, and poor digestion and metabolism, resulting from physiological and metabolic changes related to aging process. Deficiencies of essential micronutrients among the geriatric population increase their risk of developing adverse health consequences such as anemia, osteoporosis, joint pains, anorexia, weight loss, cognitive decline, and malnutrition [4–6].

There is a lack of data on the dietary intake of essential micronutrients among the geriatric population in India; hence, to fill the gap in the existing knowledge, the present study was undertaken.

Methodology

A community-based cross-sectional study was conducted during 2015–2016 in District Nainital, Uttarakhand State, India.

Published online: 20 March 2017

The district is situated at an altitude of more than 2000 m. A total of 255 geriatric subjects were enrolled from 30 clusters (villages) identified by using population proportionate to size (PPS) sampling methodology. A minimum of eight geriatric subjects in the age group of 60 and above were selected from each cluster. The geriatric subjects were identified with the help of village-level health and nutrition functionaries such as anganwadi workers, auxiliary nurse midwife, and accredited social health activists. The following exclusion criteria were adopted: (i) subjects who were unable to comprehend the questions objectively, (ii) subjects who had auditory problems leading to nonresponse, and (iii) subjects with acute morbidity condition on the day of the survey which could modify their dietary intake. An informed written consent was obtained from each subject after the explanation of the objectives and data collection parameters for the study. The study was approved by the ethical committee of All India Institute of Medical Sciences, New Delhi.

Sociodemographic Profile

A pretested structured questionnaire was administered to each geriatric subject to obtain information on sociodemographic profile such as name, sex, age, educational qualification, present occupation, monthly income of the family, and financial dependence on caregiver. The socioeconomic status of the subjects was calculated using Kuppuswamy classification (2014) [7].

Dietary Assessment

The dietary intake of essential micronutrients among the geriatric subjects was assessed using 1-day 24-h dietary recall method. The following steps were undertaken: (i) information regarding the meal pattern and the food items (cooked and uncooked) consumed by the subject was recorded; (ii) for each cooked food item consumed, the raw ingredients used for the preparation were recorded; (iii) equivalent quantities of raw ingredients used for preparation of each food item were weighed using a SECA kitchen scale and recorded; (iv) total volume of each cooked food item was recorded using standard cups; (v) the quantity of each food item consumed by the indexed subject was assessed using standard cups/spoons/chapatti models; the cups were used to aid the respondent recall the quantities consumed by the individual subject; (vi) from steps (iv) and (v), the amount of raw ingredients in grams for each food item consumed by the indexed subject was calculated; and (vii) nutritive value of the raw foods consumed was determined using the Food Composition Table from *Nutritive value of Indian foods* [8]. The person responsible for cooking the food was interviewed for assessing the dietary intake of the indexed subject. The dietary intake of macronutrients (energy, protein, fat, and carbohydrate), micronutrients (iron, calcium, magnesium, thiamine, riboflavin, niacin, vitamin C, and folic acid), and trace elements (zinc, copper, manganese, molybdenum, and chromium) by the geriatric subjects was compared with the Recommended Dietary Allowance (RDA) for Indians given by the Indian Council of Medical Research (ICMR) [1].

The dietary intake data collected using the 24-h dietary recall methodology was further substantiated with the data collected by food frequency questionnaire (FFQ) [9]. This method was utilized to elicit retrospective qualitative information on the frequency of consumption of food items in various major food groups such as cereals, pulses, green leafy vegetables, roots and tubers, fruits, milk and milk products, eggs, flesh foods, and sugar consumed during the preceding 1 year. Under each of these food groups, commonly consumed food items in the population were explained for facilitating the geriatric subject to comprehend and recall the pattern of food items consumed. The subject was asked regarding the frequency of consumption of at least one serving of food items in food groups during the last 1 year in terms of (i) number of days per week, (ii) monthly, (iii) occasionally, or (iv) never. The food group intake of the subjects was compared with the recommendations as per *Dietary Guidelines for Indians* given by the ICMR [5].

Statistical Analysis

Statistical Package for Social Sciences (SPSS) version 20.0 was utilized for conducting the statistical analysis of the data (IBM SPSS statistics for Windows. version 20. Armonk, NY: IBM Corp). The quantitative variables (24-h dietary recall data and FFQ) were treated to yield frequencies, means, and standard deviations. Student's t distribution was employed for comparison between groups for dietary parameters. Pearson's correlation was utilized to assess the association between sociodemographic profile and dietary parameters. All the data were tested at 5% level of significance.

Results

A total of 255 geriatric subjects (110 males; 145 females) were included. Out of 255 geriatric subjects, 149 (58%) were in the age group of 60–<70 years, 79 (31%) were in the age group of 70–<80 years, and 27 (11%) were more than 80 years of age. The mean age of the male and female subjects was 69.8 ± 7.6 and 67.2 ± 6.3 years, respectively. The majority of the geriatric subjects were illiterate (47%), unemployed (49%), and financially dependent (53%) and belonged to lower socioeconomic status (69%) (Table 1). Females had lower educational status, occupational level, and socioeconomic status and higher financial dependence on caregivers than males (Table 1).

Table 1 Distribution of elderly subjects according to sociodemographic profile (*n* = 255)

Sociodemographic profile	Male *n* = 110 (%)	Female *n* = 145 (%)	Total *n* = 255 (%)
Age (years)			
60–<70	59 (53.6)	90 (62.1)	149 (58)
70–<80	35 (31.8)	44 (30.3)	79 (31)
≥80	16 (14.5)	11 (7.6)	27 (11)
Marital status			
Married	100 (90.9)	64 (44.1)	164 (64)
Widowed/divorced/separated	10 (9.1)	81 (55.9)	91 (36)
Education			
Intermediate or post high school diploma	13 (11.8)	1 (0.7)	14 (6)
High school certificate	15 (13.6)	8 (5.5)	23 (9)
Middle school certificate	20 (18.8)	11 (7.6)	31 (12)
Primary school certificate	35 (31.8)	32 (22.1)	67 (26)
Illiterate	27 (24.5)	93 (64.1)	120 (47)
Present occupation level			
Skilled worker/profession	47 (42.7)	14 (9.6)	61 (24)
Semi-skilled worker	4 (3.6)	0	4 (2)
Unskilled worker	40 (36.4)	25 (17.2)	65 (25)
Unemployed	19 (17.3)	106 (73.1)	125 (49)
Family income per month (in Rs)			
≥36,997	2 (1.8)	5 (3.4)	7 (3)
18,498–36,996	10 (9.1)	11 (7.6)	21 (8)
13,874–18,497	8 (7.2)	7 (4.8)	15 (6)
9249–13,873	15 (13.6)	12 (8.3)	27 (11)
5547–9248	9 (8.1)	20 (13.7)	29 (11)
1866–5546	34 (30.9)	56 (38.6)	90 (35)
≤1,865	32 (29.0)	34 (23.4)	66 (26)
Socioeconomic class (as per Kuppuswamy Scale)			
Upper (26–29)	7 (6.3)	0	7 (3)
Upper middle (16–25)	21 (19.1)	4 (2.7)	25 (10)
Middle/lower middle (11–15)	21 (19.1)	26 (17.9)	47 (18)
Lower/upper lower (5–10)	49 (44.5)	59 (40.7)	108 (42)
Lower (<5)	12 (10.9)	56 (38.6)	68 (27)
Financially dependent			
Yes	33 (30.0)	102 (70.3)	135 (53)
No	77 (70.0)	43 (29.7)	120 (47)

Figures in parentheses denote percentages

Vegetarianism was observed among 126 (49.4%) subjects and 129 (50.6%) were nonvegetarians. The dietary intake of nutrients among the geriatric subjects assessed by 24-h dietary recall is depicted in Table 2. The prevalence of inadequate intake (<100% RDA) of essential micronutrients among geriatric subjects was found to be as follows: calcium (51%), thiamine (33%), riboflavin (64%), niacin (88%), vitamin C (42%), iron (72%), folic acid (72%), magnesium (48%), zinc (98%), copper (81%), and chromium (89%) (Table 2). A high percentage of geriatric subjects had inadequate consumption of essential micronutrient-rich food groups such as pulses (94%), vegetables (80%), fruits (98%), and milk and milk products (25%) (Table 2).

It was found that the male geriatric subjects had inadequate mean dietary intake of essential micronutrients such as niacin (68%), riboflavin (84%), folic acid (97%), zinc (49%), copper (84%), and chromium (65%) when compared with the RDA (Table 3). Similarly, the female geriatric subjects had inadequate mean dietary intake of

Table 2 Distribution of geriatric subjects according to nutrient and food group adequacy ($n = 255$)

	% RDA of nutrients		
	≥100% RDA	50–99% RDA	<50% RDA
Nutrients			
Energy	57 (22)	183 (72)	15 (6)
Protein	57 (22)	178 (70)	20 (8)
Fat	247 (97)	7 (3)	1
Iron	71 (28)	128 (50)	56 (22)
Calcium	124 (49)	94 (36)	37 (15)
Thiamine	170 (67)	81 (32)	4 (2)
Riboflavin	91 (36)	130 (51)	34 (13)
Niacin	31 (12)	183 (72)	41 (16)
Vitamin C	149 (58)	64 (25)	42 (16)
Folic acid	72 (28)	130 (51)	53 (21)
Magnesium	132 (52)	106 (42)	17 (7)
Zinc	5 (2)	118 (46)	132 (52)
Copper	48 (19)	160 (63)	47 (18)
Manganese	237 (93)	15 (6)	3 (1)
Chromium	27 (11)	105 (41)	123 (48)
Food groups			
Cereal	58 (23)	15 (61)	41 (16)
Pulse	16 (6)	92 (36)	147 (58)
Vegetables	50 (20)	101 (40)	104 (40)
(i) Green leafy vegetables			
(ii) Roots and tubers			
(iii) Other vegetables			
Fruits	4 (2)	24 (9)	227 (89)
Meat and poultry	14 (5)	0	241 (95)
Milk and milk products	192 (75)	43 (17)	20 (8)

Figures in parentheses denote percentages

essential micronutrients such as niacin (77%), iron (79%), folic acid (78%), calcium (91%), riboflavin (93%), zinc (50%), copper (72%), and chromium (57%) when compared with the RDA (Table 3). Overall, the female geriatric subjects had lower nutrient adequacy for all the nutrients than the male subjects (Table 3). It was found that females had significantly lower adequacy for iron, calcium, manganese (all $p < 0.001$), naicin, folic acid, copper (all $p < 0.01$), and vitamin C ($p < 0.05$) than the male geriatric subjects (Table 3). Both male and female geriatric subjects did not meet the recommended intake for food groups such as cereals, pulses, vegetables, and fruits (Table 4).

Dietary adequacy of all nutrients such as protein, fat, calcium, thiamine, riboflavin, niacin, iron, folic acid, magnesium, zinc, copper, manganese, chromium (all $p < 0.001$) and vitamin C ($p < 0.01$) was found to be significantly lower among subjects with inadequate energy intake as compared to subjects with adequate energy intake (Table 4). Also, with increasing energy adequacy, the nutrient adequacy for all nutrients increased (all $p < 0.01$) (Table 4).

Nutrient density is defined as the ratio of the content of a nutrient to the energy provided by the diet and usually expressed as weight of the nutrient per 1000 kcal of energy [10]. We found that the nutrient density of nutrients such as protein ($p < 0.001$), zinc, folic acid, and magnesium (all $p < 0.05$) significantly increased with increasing energy adequacy of the diet (Table 4). No significant difference was observed among the nutrient densities of all nutrients between subjects with adequate and inadequate energy intake except protein ($p < 0.001$) (Table 4).

Results from FFQ showed that the geriatric subjects did not consume food items rich in essential micronutrients such as pulses (61%), green leafy vegetables (17%), roots and tubers (70%), other vegetables (25%), fruits (16%), meat and poultry (3%) and milk and milk products (59%) regularly (more than 4 days a week) (Table 5). Comparison of FFQ with the 24-h dietary recall data showed that subjects with regular consumption of pulses had significantly higher nutrient adequacy for energy, protein, folic acid (all $p < 0.001$), thiamine, riboflavin, niacin, magnesium, zinc, copper, manganese (all $p < 0.01$), fat, vitamin C, and iron (all $p < 0.05$) in last 24 h than subjects who consumed them irregularly (Table 6). Subjects who consumed meat and poultry items regularly had significantly higher adequacy for iron ($p < 0.05$) than subjects who consumed them irregularly in last 24 h (Table 6).

We found that with improving educational level, the nutrient adequacy for essential micronutrients such as calcium, thiamine, vitamin C, iron, folic acid, magnesium, zinc, copper, manganese, chromium (all $p < 0.01$), and riboflavin ($p < 0.05$) also increased significantly among the geriatric subjects (Table 7). The subjects with higher occupational level had significantly higher nutrient adequacy for essential micronutrients such as calcium, vitamin C, copper, manganese (all $p < 0.01$), thiamine, folic acid, and chromium (all $p < 0.05$) (Table 7).

According to the economic status, subjects with higher income had significantly higher nutrient adequacy for essential micronutrients such as thiamine, magnesium, manganese (all $p < 0.01$), calcium, and vitamin C (all $p < 0.05$) and food group adequacy for fruits (all $p < 0.05$) (Table 7). Nutrient adequacy for essential micronutrients such as iron, calcium, thiamine, vitamin C, folic acid, magnesium, zinc, copper, manganese, and chromium (all $p < 0.01$) also increased significantly with improvement in socioeconomic status (Table 7). Subjects who were financially dependent on caregivers had significantly lower nutrient adequacy for essential micronutrients such as calcium, vitamin C, folic acid, manganese, and copper (all $p < 0.05$) (Table 7).

Table 3 Sex wise distribution of nutrient and food group intake amongst geriatric subjects during last 24 hours (n=255)

	Male (n=110)			Female (n=145)			p-value	Total (n=255)
	Mean ±SD (mg/d)	RDA (mg/d)	% RDA	Mean ±SD (mg/d)	RDA (mg/d)	% RDA		Mean ±SD (mg/d)
NUTRIENTS[1]								
Macronutrients								
Energy (Kcal)	1523.1±409.9	[2]	85	1338.5±350.9	[2]	82	0.267	1418.1±387.7
Protein (g)	51.1±16.6	60	85	44.1±13.4	55	80.2	0.107	47.0±15.2
Fat (g)	46.6±15.7	25	187	43.4±13.7	20	217	<0.001	44.8±14.6
Carbohydrate (g)	233.2±66.7	NA	NA	203.7±58.9	NA	NA	NA	216.4±63.9
Micronutrients								
Iron (mg)	20.0 ±14.6	17	118	16.6 ±12.3	21[3]	79	<0.001	18.0±13.4
Calcium (mg)	779.2 ± 394.7	600	130	730.3 ±380.1	800[4]	91	<0.001	751.4±386.4
Magnesium (mg)	367.8 ±149.2	340	108	308.0 ±145.5	310	99	0.106	333.7±149.8
Thiamine (mg)	1.4 ±0.5	1.2	117	1.2 ±0.4	1	117	0.882	1.3±0.4
Riboflavin (mg)	1.2 ±0.5	1.4	84	1.0 ±0.4	1.1	93	0.063	1.1±0.5
Niacin (mg)	10.9 ±3.8	16	68	9.2 ±3.0	12	77	<0.01	9.9±3.5
Vitamin C (mg)	74.6 ±67.6	40	187	57.9 ±49.2	40	145	<0.05	65.0±58.3
Folic Acid (µg)	193.5 ±110.7	200	97	156.6 ±82.6	200.0	78	<0.01	172.2±97.2
Trace Elements								
Zinc (mg)	5.9 ± 2.1	12	49	5.0 ±1.8	10	50	0.786	5.4±2.0
Copper (mg)	1.7 ±0.6	2	84	1.4 ±0.7	2	72	<0.01	1.5 ±0.6
Manganese (mg)	5.0 ±2.1	2	252	4.1 ±1.4	2	203	<0.001	4.5 ±1.8
Molybdenum (mg)	0.3 ±0.2	NA	NA	0.2 ±0.2	NA	NA	NA	0.2 ±0.1
Chromium (mg)	0.03 ±0.02	0.05	65	0.03 ±0.02	0.05	57	0.079	0.03 ±0.02
FOOD GROUPS[5]								
Cereals	206.2±80.3	270	76	172.8±60.1	210	82	0.136	187.2±71.3
Pulses and Legumes	39.6±30.6	90	47	34.7±29.5	90	40	0.089	36.8±30.0
Vegetables:	214.0±149.1	300	71	187.5±116.0	300	63	0.094	199.0±131.7
i) Green leafy vegetables	86.3±136.6			68.6±106.7				76.2±120.6
ii) Roots and Tubers	83.0±61.5			79.0±61.6				80.7±61.5
iii) Other Vegetables	44.8±76.8			39.9±52.6				42.0±64.1
Fruits	32.6±54.6	200	16	35.0±96.9	200	18	0.829	34.0±81.3
Meat and Poultry	54.3±19.5	30	181	46.3±17.7	30	154	0.348	4.4±15.4
Milk and Milk Products	344.6±195.1	300	115	332.8±206.0	300	111	0.678	337.9±201.1

[1] RDA as per ICMR Guidelines, 2010 [1]

[2] Energy requirements for geriatric subjects have been provided as per age and body weight provided by ICMR (Males: 1590-2177 Kcal, Females: 1477-1936 Kcal) as per ICMR Guidelines, 2010 [1]

[3] We have considered the RDA for non pregnant non lactating women as per ICMR Guidelines, 2010 [1]

[4] We have considered the RDA for postmenopausal female geriatric women as per ICMR Guidelines, 2010 [1]

[5] Recommendations as per Dietary Guidelines for Indians, NIN, Hyderabad, 2011 [5]

Table 4 Nutrient adequacy and density amongst geriatric subjects according to adequacy of energy intake (n=255)

	Adequate energy intake (n=57)	Inadequate energy intake (n=198)	p-value	Correlation value (r)
Nutrient adequacy				
Protein	111.2±23.0	74.1±20.0	<0.001	.813*
Fat	274.0±2.4	183.8±54.5	<0.001	.707*
Iron	124.4±77.8	87.6±70.8	<0.001	.330*
Calcium	148.1±50.7	96.4±56.4	<0.001	.516*
Thiamine	156.6± 35.1	105.7±30.3	<0.001	.774*
Riboflavin	120.2±39.4	80.1±31.7	<0.001	.608*
Niacin	96.3±24.0	66.2±20.5	<0.001	.713*
Vitamin C	195.3±155.2	153.6±142.0	<0.01	.213*
Folic Acid	117.0±48.4	77.4±45.1	<0.001	.502*
Magnesium	140.2± 58.8	92.5±34.7	<0.001	.610*
Zinc	67.4± 18.2	44.9±14.3	<0.001	.726*
Copper	106.5±38.7	68.9±23.4	<0.001	.668*
Manganese	296.3±90.3	203.2±77.1	<0.001	.641*
Chromium	78.3±34.3	55.0±36.3	<0.001	.358*
Nutrient density				
Protein	38.4±7.3	24.7±6.4	<0.001	.890*
Fat	32.2±6.2	31.7±6.7	0.621	-.026
Iron	12.1±6.5	12.9±9.9	0.543	-.022
Calcium	536.5±165.0	522.8±241.6	0.624	.066
Thiamine	0.9±0.1	0.9±0.2	0.832	.040
Riboflavin	0.8±0.2	0.8±0.2	0.665	.054
Niacin	6.9±1.1	7.0±1.3	0.922	.075
Vitamin C	40.8±31.9	48.6±45.9	0.147	-.116
Folic Acid	122.0±43.3	118.1±58.2	0.642	.129**
Magnesium	236.7±71.2	230.4±61.4	0.507	.127**
Zinc	3.9±0.8	3.8±0.8	0.434	.124**
Copper	1.1±0.3	1.1±0.3	0.315	.092
Manganese	3.1±0.6	3.1±0.8	0.830	.088
Chromium	0.02±0.01	0.02±0.01	0.975	.011

Values are expressed as Mean±SD

**Correlation is significant at the 0.01 level*

***Correlation is significant at the 0.05 level*

Table 5 Distribution of geriatric subjects according to frequency of consumption of food items consumed in different food groups in the past 1 year ($n = 255$)

Food groups	Frequency of consumption			
	Regular (5–7 days a week)	Irregular (1–4 days a week)	Occasionally (less than once a week)	Never
Cereals	255 (100)	0	0	0
Pulses and Legumes	156 (61)	90 (35)	6 (2)	3 (1)
Vegetables:				
(i) Green leafy vegetables	44 (17)	187 (73)	23 (9)	1
(ii) Roots and tubers	179 (70)	65 (25)	11 (4)	0
(iii) Other Vegetables	64 (25)	161 (63)	30 (12)	0
Fruits	42 (16)	139 (54)	74 (29)	0
Meat and poultry	10 (3)	68 (27)	173 (68)	4 (2)
Milk and milk products	152(59)	34 (13)	53 (21)	16 (6)

Figures in parentheses denote percentages

Discussion

The role of essential micronutrients in the maintenance of nutritional status and diseases is well recognized [1, 2]. There is lack of data on the dietary intake of essential micronutrients among the geriatric population in India. Data on dietary intake of essential micronutrients can help in assessing the magnitude of clinical and subclinical nutrient deficiencies among the geriatric population. This is possibly the first study conducted in which the dietary intake of all essential micronutrients has been studied.

The present study showed that high prevalence of geriatric subjects had inadequate dietary intake of essential micronutrients and micronutrient-rich food groups as shown in Table 2. In addition, the mean nutrient adequacy of essential micronutrients such as riboflavin (89%), niacin (73%), folic acid (86%), zinc (50%), copper (77%), and chromium (60%) in the diet was found to be low among the geriatric subjects residing in rural district of Uttarakhand, India. Poor quality of the diet in terms of inadequate intake of food items rich in essential micronutrients such as vegetables, fruits, meat and poultry, cereals, and pulses in the last 24 h may have resulted in these inadequate nutrient intakes. In 1996–1997, a nationwide survey conducted in India by the National Nutrition Monitoring Bureau reported that the diets of the tribal geriatric population were deficient in essential micronutrients such as iron, vitamin A, thiamine, riboflavin, folic acid, and niacin [11]. Community-based studies conducted in India have also reported low dietary adequacy of zinc (30–50%) and copper (90%) among the geriatric populations [12–14].

Earlier studies have documented a high prevalence of iron deficiency anemia (16–86%) among the geriatric subjects across different parts of India [15–19]. Although the Indian diet has adequate iron content, the low bioavailability of iron (5–8%) due to inhibitory factors such as phytates, tannins, and oxalates present in the cereal-based diets may explain the high prevalence of anemia among the geriatric subjects of the country [20, 21].

We observed that 6% ($n = 15$) and 72% ($n = 183$) of the subjects were consuming <50% and 50–99% of the total energy requirements in the diet, respectively. Only 22% ($n = 57$) of the geriatric subjects had adequate energy intake according to their RDA. Since the total calorie content of the diet is a proxy measure of the total quantity of the food consumed by an individual, the present study suggested that total quantity of the food consumed by majority (78%) of the geriatric population was low. Further, inadequate dietary intake of energy was associated with significantly lower adequacy for all essential micronutrients (Table 4). We observed that subjects with adequate energy intake met the nutrient adequacy for essential micronutrients except zinc, niacin, and chromium. Also, with increasing energy adequacy, the nutrient density for nutrients such as protein, zinc, folic acid, and magnesium improved significantly. In concordance with the present study, an earlier study conducted in Europe also documented low nutrient density in diets with inadequate energy density [22]. This suggested that both total energy and nutrient density of the diet are important parameters in meeting the dietary requirements of essential micronutrients.

The FFQ revealed that food items rich in essential micronutrients such as pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, meat and poultry, and milk and milk products were consumed in low frequency by the geriatric population. Although half of the geriatric subjects were nonvegetarians, majority of the subjects did not consume nonvegetarian food items regularly (more than 5 days a week) possibly due to high cost of these food items.

Since FFQ relies heavily on long-term memory, it may not provide conclusive results for assessing dietary pattern in older adults [23, 24]. Hence, we compared the FFQ with the results of the 24-h dietary recall method. We found that according to the FFQ, subjects with regular consumption of

Table 6 Comparison of frequency of consumption of food items consumed in different food groups using food frequency questionnaire with % RDA of nutrients using 24-h dietary recall of the subjects ($n = 255$)

% RDA of nutrients	Pulse			Green leafy vegetables			Roots and tubers			Other vegetables	
	Regular[a] ($n = 156$)	Irregular[b] ($n = 99$)	p value	Regular[a] ($n = 44$)	Irregular[b] ($n = 211$)	p value	Regular[a] ($n = 179$)	Irregular[b] ($n = 76$)	p value	Regular[a] ($n = 64$)	Irregular[b] ($n = 191$)
Energy	89.1 ± 22.8	80.1 ± 21.0	<0.001	85.5 ± 24.5	83.2 ± 21.7	0.534	84.7 ± 20.7	83.1 ± 22.8	0.595	84.6 ± 20.1	83.2 ± 22.8
Protein	89.4 ± 27.9	78.0 ± 23.5	<0.001	84.1 ± 27.9	82.0 ± 25.5	0.625	84.5 ± 26.8	81.5 ± 25.5	0.403	84.1 ± 23.7	81.9 ± 26.6
Fat	215.3 ± 69.9	196.8 ± 65.5	<0.05	202.5 ± 58.9	204.3 ± 69.6	0.877	201.7 ± 64.6	204.9 ± 69.2	0.734	212.9 ± 63.2	200.9 ± 69.1
Calcium	116.6 ± 62.2	102.4 ± 56.7	0.067	97.5 ± 47.2	110.1 ± 61.3	0.198	106.6 ± 52.0	108.5 ± 62.1	0.822	101.8 ± 44.7	110.0 ± 63.3
Thiamine	126.2 ± 41.1	111.2 ± 34.6	<0.01	121.0 ± 44.4	116.2 ± 36.5	0.448	119.8 ± 36.6	115.9 ± 38.5	0.449	118.4 ± 30.6	116.6 ± 40.1
Riboflavin	98.3 ± 41.5	83.2 ± 33.6	<0.01	92.8 ± 35.4	88.3 ± 38.0	0.465	89.7 ± 36.6	88.8 ± 38.0	0.854	90.0 ± 38.1	88.7 ± 37.4
Niacin	78.0 ± 25.9	69.7 ± 23.6	<0.01	74.1 ± 27.8	72.7 ± 24.2	0.738	73.7 ± 23.2	72.6 ± 25.5	0.742	73.2 ± 19.0	72.8 ± 26.5
Vitamin C	185.4 ± 159.8	148.5 ± 134.9	<0.05	193.0 ± 188.3	156.5 ± 1351	0.132	169.4 ± 163.4	160.0 ± 138.1	0.638	177.3 ± 184.0	157.9 ± 130.8
Iron	110.5 ± 80.6	86.5 ± 68	<0.05	98.1 ± 66.9	95.3 ± 75.4	0.82	97.0 ± 73.0	95.3 ± 74.5	0.869	97.2 ± 58.8	95.3 ± 78.5
Folic acid	99.4 ± 56.5	77.9 ± 41	<0.001	95.8 ± 54.4	84.3 ± 47.3	0.154	93.7 ± 51.3	83.1 ± 47.3	0.111	94.4 ± 52.3	83.5 ± 47.2
Magnesium	112.8 ± 54.4	97.0 ± 38.2	<0.01	106.6 ± 44.2	102.4 ± 46.2	0.588	109.8 ± 58.0	100.3 ± 39.3	0.13	102.8 ± 29.6	103.3 ± 50.1
Zinc	53.8 ± 19.0	47.4 ± 16.8	<0.01	52.4 ± 21.6	49.4 ± 17.1	0.304	50.9 ± 16.8	49.5 ± 18.4	0.582	50.7 ± 15.6	49.6 ± 18.6
Copper	84.6 ± 37.5	72.7 ± 26.4	<0.01	79.4 ± 33.1	76.9 ± 31.4	0.633	79.9 ± 27.7	76.2 ± 33.2	0.389	79.9 ± 24.6	76.4 ± 33.7
Manganese	247.7 ± 102.9	208.9 ± 75.4	<0.01	238.5 ± 117.5	221.0 ± 81.8	0.235	228.0 ± 81.5	222.3 ± 92.1	0.64	230.6 ± 67.7	221.8 ± 95.1
Chromium	65.5 ± 39.7	56.8 ± 35.1	0.068	56.3 ± 28.4	61.0 ± 38.7	0.451	64.5 ± 42.2	58.3 ± 34.7	0.223	57.4 ± 27.5	61.1 ± 39.8

% RDA of nutrients	Other vegetables	Fruits			Milk			Meat and poultry		
	p value	Regular[a] ($n = 42$)	Irregular[b] ($n = 213$)	p value	Regular[a] ($n = 152$)	Irregular[b] ($n = 103$)	p value	Regular[a] ($n = 10$)	Irregular[b] ($n = 245$)	p value
Energy	0.674	90.5 ± 21.0	82.2 ± 22.2	<0.05	85.1 ± 20.8	82.6 ± 23.0	0.372	83.8 ± 22.4	78.9 ± 16.7	0.493
Protein	0.556	85.1 ± 26.7	81.9 ± 25.7	0.46	83.8 ± 23.9	81.5 ± 27.1	0.475	82.8 ± 25.9	72.2 ± 22.0	0.203
Fat	0.221	217.1 ± 58.6	201.4 ± 69.2	0.168	207.3 ± 68.4	201.7 ± 67.4	0.521	205.2 ± 67.7	173.5 ± 64.3	0.147
Calcium	0.263	105.1 ± 52.3	108.5 ± 60.6	0.737	110.7 ± 57.0	106.1 ± 60.8	0.541	108.1 ± 59.1	104.9 ± 65.2	0.868
Thiamine	0.696	121.7 ± 41.0	116.1 ± 37.3	0.384	118.2 ± 38.6	116.3 ± 37.6	0.697	117.7 ± 38.0	101.3 ± 32.3	0.182
Riboflavin	0.823	93.1 ± 34.8	88.3 ± 38.0	0.447	93.2 ± 40.2	86.2 ± 35.4	0.144	89.6 ± 37.6	76.0 ± 32.9	0.261
Niacin	0.918	75.3 ± 27.3	72.5 ± 24.3	0.496	75.025.4	71.5 ± 24.4	0.278	73.3 ± 25.0	62.5 ± 16.7	0.177
Vitamin C	0.358	174.7 ± 150.2	160.5 ± 145.2	0.563	158.3 ± 128.9	165.8 ± 156.7	0.689	164.0 ± 147.5	133.7 ± 99.4	0.52
Iron	0.862	97.9 ± 78.1	95.4 ± 73.3	0.841	97.2 ± 71.4	94.8 ± 75.8	0.804	96.6 ± 75.2	75.6 ± 23.5	<0.05
Folic acid	0.122	92.4 ± 44.7	85.0 ± 49.4	0.37	94.6 ± 54.4	80.6 ± 43.6	<0.05	86.4 ± 48.6	82.0 ± 50.9	0.777
Magnesium	0.932	102.0 ± 40.0	103.4 ± 46.9	0.855	105.0 ± 36.8	101.9 ± 51.1	0.594	103.4 ± 45.9	97.1 ± 43.6	0.671
Zinc	0.682	50.9 ± 20.1	49.7 ± 17.5	0.684	51.1 ± 17.6	49.1 ± 18.1	0.368	50.2 ± 18.1	42.8 ± 11.6	0.203
Copper	0.447	80.3 ± 28.1	76.7 ± 32.3	0.506	78.6 ± 27.3	76.4 ± 34.4	0.578	77.8 ± 32.0	65.6 ± 19.7	0.234
Manganese	0.418	227.4 ± 109.6	223.3 ± 84.6	0.783	232.7 ± 94.7	218.1 ± 84.7	0.198	224.5 ± 89.3	210.7 ± 83.9	0.63
Chromium	0.495	53.5 ± 24.4	61.5 ± 39.0	0.2	63.8 ± 38.6	57.7 ± 36.0	0.195	60.7 ± 37.6	47.6 ± 16.2	0.276

Values are expressed as mean ± SD

[a] Regular: daily to five times a week

[b] Irregular: less than five times a week

Table 7 Association of sociodemographic profile with nutrient and food group intake of geriatric subjects ($n = 255$)

	Education	Present occupation	Income	Socioeconomic status	Functional dependence
Nutrients					
Energy	0.155**	0.06	0.044	0.078	0.042
Protein	0.282*	0.153**	0.132**	0.201*	0.104
Fat	0.130**	−0.043	0.190*	0.06	−0.069
Iron	0.193*	0.102	0.072	0.170*	0.115
Calcium	0.292*	0.243*	0.146**	0.279*	0.158**
Thiamine	0.218*	0.145**	0.165*	0.192*	0.015
Riboflavin	0.128**	0.012	0.096	0.049	0.021
Niacin	0.109	0.009	0.122	0.067	−0.072
Vitamin C	0.181*	0.170*	0.138**	0.203*	0.147**
Folic acid	0.276*	0.137**	0.089	0.181*	0.142**
Magnesium	0.234*	0.106	0.192*	0.194*	0.036
Zinc	0.221*	0.103	0.12	0.170*	−0.013
Copper	0.284*	0.168*	0.087	0.192*	0.137**
Manganese	0.383*	0.257*	0.166*	0.314*	0.150**
Chromium	0.193*	0.144**	0.098	0.179*	0.114
Food groups					
Cereal	0.174*	0.032	0.121	0.098	−0.031
Pulse	−0.036	0.035	−0.009	0.032	−0.158*
Vegetables	0.11	0.119	0.057	0.128*	0.099
(i) Green leafy vegetables					
(ii) Roots and Tubers					
(iii) Other Vegetables					
Fruits	0.077	−0.042	0.136**	0.007	0.021
Meat and poultry	−0.297	−0.213	−0.186	0.388	0.044
Milk and milk products	−0.188*	−0.244*	0.078	−0.186*	−0.222*

*Correlation (r) is significant at the 0.01 level

**Correlation (r) is significant at the 0.05 level pulses were associated with higher adequacy for the most of the essential micronutrients over last 24 h (Table 6). Increased availability, access, and consumption of pulses in poor rural elderly populations in India should be included as part of the strategy for public health intervention. Interestingly, higher frequency of consumption of meat and poultry products was found to be associated with significantly higher iron adequacy over last 24 h as documented in previous studies [25 26]. Therefore, infrequent consumption of food items rich in essential micronutrients may increase the risk of developing multiple micronutrient deficiencies and their related conditions among the geriatric subjects.

We found that higher educational level, level of occupation, income, and socioeconomic status were associated with higher nutrient adequacy of the essential nutrients in the diet. Lower educational status, occupational level, and socioeconomic level in addition with higher financial dependency on caregivers observed amongst female geriatric subjects may be potential determinants of malnutrition and micronutrient deficiencies amongst them, as documented earlier in the present study (Table 3). We observed that consumption of fruits increased significantly with higher income. A high percentage of inadequate consumption of fruit may have been found due to their unaffordable cost by majority of the study population belonging to the low-income group. Studies conducted in other parts of India have reported thatgeriatric subjects with higher educational and occupational level have a better nutritional status since they are aware regarding the importance of healthy diet and are able to make appropriate food choices [27–34]. Members of the geriatric population belonging to lower income and socioeconomic status may face issues related to reduced food availability and food security, leading to lower consumption of food rich in essential micronutrients as found in earlier studies [29, 30, 35, 36].

In conclusion, the present study documented that the dietary intake of essential micronutrients among the geriatric population was inadequate due to poor quality and quantity of the predominantly cereal-based diet consumed in low-income countries like India. Prevention of noncommunicable diseases through age-related dietary modifications and maintenance of healthy nutritional status is not prioritized in the current programs and policies of the country. Hence, there is a need for initiating, targeting, and strengthening public health interventions for promotion of daily consumption of adequate quantities of foods and food items rich in essential micronutrients through nutrition counseling to the geriatric subjects. Also, efforts need to be made for increasing the availability and access to food to geriatric subjects through community support. This could aid in the maintenance of nutritional status and delay in the onset of diet-related illnesses among the geriatric population of the country.

Compliance with Ethical Standards

Funding Agency We are extremely grateful to the Indian Council of Medical Research, Government of India (vide letter no: 54/3/TF/CFP/AIIMS/GER/2011-NCD-II) for providing us the financial grant for conducting this study.

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

References

1. Indian Council of Medical Research (2010) Nutrient requirements and recommended dietary allowances for Indians. National Institute of Nutrition, Hyderabad, India
2. Institute of Medicine (IOM) (2000) Dietary reference intakes of vitamin A, vitamin K, As, B, Cr, Cu, I, Fe, Zn. Food and Nutrition Board. National Academy Press, Washington DC. Accessed from: https://www.ncbi.nlm.nih.gov/books/NBK222310/
3. Arlappa N, Balakrishna N, Kumar S, Brahmam GN, Vijayaraghavan K (2005) Nutritional status of the tribal elderly in India. J Nutr Elder 25(2):23–39
4. Ahmed T, Haboubi N (2010) Assessment and management of nutrition in older people and its importance to health. Clin Interv Aging 5:207–216
5. Indian Council of Medical Research (2011) Dietary guidelines for Indians—a manual. National Institute of Nutrition, Hyderabad, India
6. Kerketta AS, Bulliyya G, Babu BV, Mohapatra SS, Nayak RN (2009) Health status of the elderly population among four primitive tribes of Orissa, India: a clinico-epidemiological study. Z Gerontol Geriatr 42(1):53–59. doi:10.1007/s00391-008-0530-2
7. Oberoi SS (2015) Updating income ranges for Kuppuswamy's socio-economic status scale for the year 2014. Indian J Public Health 59(2):156
8. Indian Council of Medical Research (2010) Nutritive value of Indian foods. National Institute of Nutrition, Hyderabad, India
9. Thimmayama BVS (1987) A handbook of guidelines in socio-economic and diet survey. National Institute of Nutrition, Hyderabad, India
10. Institute of Medicine (US) (2000) DRI dietary reference intakes: applications in dietary assessment. Subcommittee on Interpretation and Uses of Dietary Reference Intakes, Institute of Medicine (US) Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. National Academies Press, Washington (DC)
11. Indian Council of Medical Research (2000) National Nutrition Monitoring Bureau. Special report on elderly and adolescents. NNMB Technical Report No.20. Accessed from: http://nnmbindia.org/NNMB-PDF%20FILES/Special_Report_on_Elderly&_Adolescents%20Diet_&_Nutritional_St.pdf. Accessed on 18th Nov 2016
12. Sachdeva R, Grewal S, Kochhar A (2006) Efficacy of nutrition counselling on the nutritional and haemotological profile of elderly males of urban and rural areas. J Hum Ecol 20(1):37–41

13. Rajhans K, Sharma R (2016) Mineral intake of the elderly (60-80 years) from central India. International Journal of Latest Research in Science and Technology 5(2):75–79
14. Nambiar SV, Seshadri S (2004) Dietary patterns and its relation to disease profile in postmenopausal women. Indian Journal of Gerontology 18(1):59–72
15. Bhasin A, Rao MY (2011) Characteristics of anemia in elderly: a hospital based study in south India. Indian Journal of Hematology and Blood Transfusion 27(1):26–32
16. Kishore S, Garg BS (1996) Sociomedical problems of aged population in a rural area of Wardha district. Indian J Public Health 41(2):43–48
17. Garg BS, Gupta SC, Mishra VN, Singh RB (1982) A medico-social study of aged in urban area. Ind Med Gazette 16:90–95
18. Bharati DR, Pal R, Rekha R, Yamuna TV, Kar S, Radjou AN (2011) Ageing in Puducherry, South India: an overview of morbidity profile. Journal of Pharmacy and Bioallied Sciences 3(4):537
19. Joshi K, Kumar R, Avasthi A (2003) Morbidity profile and its relationship with disability and psychological distress among elderly people in northern India. Int J Epidemiol 32(6):978–987
20. Agte V, Jahagirdar M, Chiplonkar S (2005) Apparent absorption of eight micronutrients and phytic acid from vegetarian meals in ileostomized human volunteers. Nutrition 21(6):678–685
21. Thankachan P, Walczyk T, Muthayya S, Kurpad A, Hurrell R (2008) Iron absorption in young Indian women: the interaction of iron status with the influence of tea and ascorbic acid. Am J Clin Nutr 87(4):881–886
22. de Groot CP, van den Broek T, van Staveren W (1999) Energy intake and micronutrient intake in elderly Europeans: seeking the minimum requirement in the SENECA study. Age Ageing 28(5): 469–474
23. Adamson AJ, Collerton J, Davies K, Foster E, Jagger C, Stamp E, Mathers JC, Kirkwood T (2009 Feb 1) Nutrition in advanced age: dietary assessment in the Newcastle 85+ study. Eur J Clin Nutr 63: S6–18
24. Dietary Assessment Primer (2017) Food frequency questionnaire. National Institutes of Health, National Cancer Institute. Accessed from: https://dietassessmentprimer.cancer.gov/. Accessed on: 6th Jan 2017
25. McEvoy CT, Temple N, Woodside JV (2012) Vegetarian diets, low-meat diets and health: a review. Public Health Nutr 15(12):2287–2294
26. Shridhar K, Dhillon PK, Bowen L, Kinra S, Bharathi AV, Prabhakaran D, Reddy KS, Ebrahim S (2014) Nutritional profile of Indian vegetarian diets–the Indian Migration Study (IMS). Nutr J 13(1):1–9
27. Mathew AC, Das D, Sampath S, Vijayakumar M, Ramakrishnan N, Ravishankar SL (2016) Prevalence and correlates of malnutrition among elderly in an urban area in Coimbatore. Indian J Public Health 60(2):112
28. Shivraj M, Singh VB, Meena BL, Kusum S, Neelam M, Dayal S (2014) Study of nutritional status in elderly in Indian population. Int J current research 6(11):10253–10257
29. Boulos C, Salameh P, Barberger-Gateau P (2014) Factors associated with poor nutritional status among community dwelling Lebanese elderly subjects living in rural areas: results of the AMEL study. J Nutr Health Aging 18(5):487–494
30. Ferdous T, Kabir ZN, Wahlin A, Streatfield K, Cederholm T (2009) The multidimensional background of malnutrition among rural older individuals in Bangladesh—a challenge for the Millennium Development Goal. Public Health Nutr 12(12):2270–2278
31. Feldblum I, German L, Castel H, Harman-Boehm I, Bilenko N, Eisinger M, Fraser D, Shahar DR (2007) Characteristics of undernourished older medical patients and the identification of predictors for undernutrition status. Nutr J 6(1):1
32. Timpini A, Facchi E, Cossi S, Ghisla MK, Romanelli G, Marengoni A (2011) Self-reported socio-economic status, social, physical and leisure activities and risk for malnutrition in late life: a cross-sectional population-based study. J Nutr Health Aging 15(3):233–238
33. Kikafunda JK, Lukwago FB (2005) Nutritional status and functional ability of the elderly aged 60 to 90 years in the Mpigi district of central Uganda. Nutrition 21(1):59–66
34. Busselman KM, Holcomb CA (1994) Reading skill and comprehension of the dietary guidelines by WIC participants. J Am Diet Assoc 94(6):622–625
35. Bawadi HA, Tayyem RF, Dwairy AN, Al-Akour N (2012) Prevalence of food insecurity among women in northern Jordan. J Health Popul Nutr 30(1):49–55
36. Tessfamichael D, Gete AA, Wassie MM (2014) High prevalence of undernutrition among elderly people in northwest Ethiopia: a cross sectional study. J Nutrition Health Food Sci 2(4):1–5