Nutritional status and dietary intake of the population aged 1-60 years during the COVID-19 pandemic in Sri Lanka

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(Keywords: malnutrition, triple burden of malnutrition, overweight, obesity, Sri Lanka, dietary adequacy, population aged 1-60, micronutrients, COVID-19)

Abstract

Background: There is a co-existence of different forms of malnutrition leading to a Triple Burden of Malnutrition (TBM) in Sri Lanka. Accessing basic needs and services was a challenge during COVID-19 pandemic, which led to issues in food security with an effect on nutrition status of the population.

Objectives: To estimate the prevalence of malnutrition and dietary intakes of the population aged 1 to 60 years.

Methods: This study was conducted in 2021. A multistage cluster sample was drawn to represent households at national level using 75 clusters, and 24-hour dietary recalls were compared with estimated average requirements of different age groups. Height and weight of all selected participants were measured.

Results: A total of 1776 households and 2991 individuals were studied. The prevalence of wasting, stunting and overweight of children aged 1-4 years (n=486) was 14%, 16.3% and 0.8% respectively. Thinness, stunting, overweight and obesity of children aged 5-9 years (n=388) was 21.4%, 8.5%, 5.2%, 5.1%; children aged 10-17 years (n=355) was 21.1%, 14.1%,11%, 8.2%; and adults aged 18-60 years (n=1762) was 9.9%, 5.4%, 32.6% and 11.5% respectively. Dietary intake gaps were minimal with energy and protein while it was wider with majority of vitamins, iron and calcium. Stunting of children aged 1-4 years was significantly associated with the low calcium and iron intakes.

Conclusions: The presence of TBM amongst children and adults were observed with a dietary gap of essential micronutrients. This study highlights the need to re-orient the nutritional interventions to control TBM at population level.

Background

Nutritional indicators are key factors which directly correlate with the development of a country [1]. The coexistence of undernutrition (wasting/thinness and stunting), micronutrient deficiencies, and obesity in the same community or even in the same household are defined as the Triple Burden of Malnutrition (TBM) [2]. Sri Lanka has been experiencing Triple Burden of Malnutrition (TBM) and increasing non-communicable diseases during the past few decades due to changes of food patterns at both individual and households levels [3,4]. The COVID-19 pandemic further amplified these changing food patterns due to drastic changes in lifestyle and limited access to food during the quarantine periods [5].

The available national level data regarding food consumption is very limited. As per the World Health Organisation (WHO) Triple Billion Goals (TBG), newly formulated data will be useful in developing new policies for the purpose of combating non-communicable diseases (NCD) and malnutrition in the country. This will also help to achieve the Sustainable Development Goals (SDG-3) of a country by improving the nutritional status of the population [6]. Thus, it was important to conduct a dietary survey with the primary objective of assessing the food consumed at household level in Sri Lanka, and to plan specific intervention programmes to improve the health and nutrition status of its citizens. Hence this study was conducted, aiming to assess the nutritional status and nutrient intake among households in Sri Lanka.

Methods

A descriptive cross-sectional study was carried out in all 25 districts in Sri Lanka. Households (HH) were

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identified using a cluster sampling method. A household was defined as a group of people who share a common cooking pot. The following were excluded when selecting the sample: people who were terminally ill; tube fed persons; had a physical disability that would affect either height or weight measurement; those eligible children whose guardians/parents had declined consent to any component of the survey. The minimum sample size for each age group was drawn as recommended globally for dietary studies [7,8], which was 260 for each defined age groups in dietary reference intakes tables [9]. A total of 1800 households (HH) were planned to be recruited, considering the minimum sample size of 520 children under five, considering that the mean number of household members (4.3) and 8.5% of the population were children under five years [3]. The sampling frame was the list of Grama Niladari Divisions (GND) in each district, which is the smallest administrative unit, consisting of approximately 1000 population. A multistage cluster sampling procedure was used to identify the households to be included. As the first stage, from each of the 25 districts, a total of 75 GNDs were identified using the probability proportional to size sampling technique. To identify the eligible participants, 24 HH were randomly selected from each cluster.

Selecting households involved two steps. As the first step in identifying eligible households, the 'starting point' was randomly selected from the list of households in the GND. Every other household was numbered from the right side to the starting point. Consent and contact numbers were obtained from the selected household. Selected HH were interviewed via telephone due to COVID-19 restrictions to obtain the basic and dietary information. The 2nd step was household level anthropometric measurements of children aged 1-4 years; children aged 5-9 years; children aged 10-17 years; adults aged 18-60 years. Data collection period was from 15th September to 21st December 2021.

The first screening call was made by enumerators to recruit the consented households to the study as well as to fix a convenient date and time for the telephone interview. The second call was taken to administer the pretested electronic based questionnaire. The mother or the person who prepares family food of each selected household was interviewed. Third call was taken to obtain the 24-hour dietary assessment using an electronic program prepared by the Medical Research Institute (MRI), using 2021 Sri Lankan food composition tables [10] by doctors with nutrition postgraduate degree. Participants were not specifically informed that the third call was to collect dietary information to prevent changes in consumption patterns. Details of raw ingredients used to prepare food items were obtained and converted to cooked food based on information provided by the participants or based on standard recipes [11,12,13]. Food consumed outside the household was estimated using a set of household measures (standard cups and spoons) suited to the Sri Lankan setting. Enquiry was made from the person who regularly cooks and serves the food regarding information on different food preparation methods and consumption pattern during the previous day (reference day) at breakfast, lunch, snacks and dinner. Each ingredient used during the food preparation was noted. The extent of the dilution of coconut milk was assessed, and the preparation of calorie dense foods by adding fats and oils were noted and recorded. Raw ingredients used for each preparation were quantified in terms of grams using the standardised cups and spoons. Total amount cooked and quantity of foods consumed such as roti, bread, biscuits, string hoppers, hoppers, dosai etc. was recorded in terms of numbers/ number of slices. Intake of other food preparations by each individual member of the family was assessed using the same standardised cups and spoons. It was ensured that the reference day was not a festival, or any other day of celebration and data collection was spread throughout the weekdays and weekends. Freshness of coconut, fish and certain fruits was also noted. Leftover food and its subsequent consumption, if any, on the same reference day was recorded. Guests partaking of food or family members not taking food on the reference day were also noted. Dietary supplement data was not included. Around 10% of dietary data was repeated during the measuring of household members by the trained enumerators to ensure the validity of information.

As the second step, all eligible participants from each age group, from each HH was measured. Men were measured one in 3 HHs to fulfil the sample size. However, women in the majority of HHs were interviewed to collect dietary data and it was decided to collect anthropometric data of all the women for provincial level representation. Investigators visited the selected HHs and the weight and length/height of all the selected participants were measured by specially trained measurers using standardized procedure. Weight was measured using Seca electronic scale (minimum 50g) and length/height was measured using stadiometers (minimum 1cm). Weighing instruments were calibrated in each day of the morning using standard weights. Standard WHO protocols for measuring height and weight of children and women were applied [14].

Ethics approval was obtained from the Ethics Review Committee, MRI. Prior approval was obtained from the health authorities.

Data analysis

Anthropometric indicators of length/height-for-age, weight-for-age and weight-for-length/height was determined for all children aged 1 to 4 years using 2006 WHO growth standards [14]. For children aged 5-17 years, BMI-for-age/sex and height-for-age-sex was determined using WHO 2018 growth standard [15]. BMI was calculated for people ≥18 years and grouped as <18.5 (thin), 18.5-24.9 (normal), 25.0-29.9 (overweight) and ≥30.0

(obesity) as recommended by WHO. Adult stunting was defined as height <145 cm [12].

Based on daily energy requirement of each individual, calorie coefficient values were assigned according to age, gender and activity. The value assigned for an adult man engaged in sedentary work was one consumption unit (1 CU) i.e. average calorie requirement (AR) per CU was 2340 kcal. For other groups the value forms a fraction of this unit as shown in Table 1 [16]. Activity levels were accounted for adults via the information obtained from the standard questionnaire.

Table 1. Coefficient for computing calorie requirement of different groups

Group	*Energy requirement (kcal/day) [4]*	*CU units* [15]
Adult man (sedentary)	2340	1.0
Adult man (moderately active)	2840	1.2
Adult man (very active)	3340	1.4
Adult female (sedentary)	1890	0.8
Adult female (moderately active)	2280	1.0
Adult female (very active)	2680	1.1
Adolescent male (15-17 years)	3020	1.3
Adolescent male (11-14 years)	2390	1.0
Adolescent female (15-17 years)	2400	1.0
Adolescent female (11-14 years)	2180	0.9
Children (7-10 years)	1580	0.7
Children (4-6 years)	1290	0.6
Children (1-3 years)	990	0.4

The total CUs of each household were calculated by adding the CUs of all the members present on the date of interview according to different age group, sex and physical activity level [17]. The nutrient intakes of each individual were calculated as per CU as follows.

Daily nutrient intake of each individual = total nutrient intake of the household × CU of the individual / total CU.

Conversion factor (CF) was calculated as follows to identify the changes happened during the cooking such as water absorption, water reduction and fat absorption.

CF of the food = weight of the raw food ingredients in the preparation (g) / total cooked quantity (volume) of that preparation.

Individual intake (g) (raw equivalents) = CF of the food × volume of cooked food.

Raw food was taken as it is. Effect of precooking and/or cooking process on nutrient retention or loss was accounted for using coefficient factors (retention factor). Foods were converted to nutrients using Sri Lankan food composition tables 2021 [10]. Intake data was expressed in grams or mg or µg/ person per day. Percentage of adequate intake was calculated from the median intake of each nutrient divided by average requirement (AR) for Sri Lankans. Reference intake (RI) was taken when AR was not available [5].

Data was analysed using SPSS (version 22.0, IBM, Inc) software package. Frequency, percentage, mean (SD) and median (25^{th} -75^{th} percentiles) and for dietary intake, 10^{th} percentile as low intake and 90^{th} percentile as upper intake was used to present the data [18]. Chi square and Kruskal Wallis tests were applied and a probability level of $P<0.05$ was used to indicate statistical significance in all analyses.

Results

A total of 1766 households were included. Table 2 presents basic characteristics, dietary preferences, and activity levels of the household members.

The prevalence of stunting was highest in children aged 1-4 years (16.3%). The prevalence of wasting/ thinness was highest in children aged 5-9 years (21.4%). The prevalence of overweight and obesity in adults aged 18-60 years were 32.6% and 11.5% respectively (Table 3). There was no significant difference between male and female except with overweight of children aged 10-17 years (13.0% in male vs. 9.3% in female) and obesity of adults 18-60 years (13.4% in female vs. 5.6% in male).

Median energy intake among all population groups were inadequate than recommended and highest inadequacy was reported among children aged 10-17 years (82.0%). Median intake of protein exceeded the AR in all age groups except among children aged 10-17 years, which was 88.6% (Table 4). Median intake of carbohydrate was 301.6g and fat was 46.6g among adults aged 18-60 years, fulfilling 105.7% and 63.1% recommended intakes respectively. The total median fibre intake was adequate in all population groups. Around 20% of recommended fibre intake consisted of soluble fibre and rest from insoluble fibre.

Table 5 shows median vitamin intake was inadequate than recommended across all the age groups except vitamin B_{12} intake, which was over 100%. Vitamin A intake was lowest in children aged 1-4 years. The lowest intakes of thiamine, riboflavin, niacin and folate was found among children aged 10-17 years.

Calcium, iron and iodine intake was inadequate than recommended in all age groups. The lowest calcium (29%) and iron (50.5%) were observed in children aged 10-17 years. Zinc, selenium and magnesium intakes were above 100%. However, 90^{th} percentile of selenium intake is within the upper tolerable intake of 300µg (Table 6).

Table 2. Basic characteristics of households

Basic HH characteristics	*Mean / %*
Ethnicity (n=1776)	
Sinhala	76.9
Tamil	19.0
Muslim	3.5
Other (Malay, Burgher)	0.5
Mean (SD) number of household members	4.5 (1.4)
Mean (SD) number of household members earning	1.5 (0.7)
Type of income (n=1776)	
Monthly	37.5
Daily irregular	32.6
Other	29.9
Median household income LKR (25^{th} -75^{th} percentile)	35,000 (20,000-50,000)
Education of wife of head of HH (n=1767)	
No formal schooling	1.2
Grade 1-5	7.6
Grade 6-11	24.0
Ordinary level (O/L) completed	35.2
Advanced level (A/L) completed	23.2
Diploma / degree	7.6
Education of head of HH (n=1765)	
No formal schooling	1.7
Grade 1-5	10.3
Grade 6-11	29.1
O/L completed	37.1
A/L completed	16.6
Diploma/degree	4.7
Occupation of head of HH (n=1641)	
Managers / Professionals	6.1
Technicians and associate professionals	3.6
Clerical support workers / service and sales workers	13.0
Skilled agricultural, forestry and fishery workers	13.6
Craft and related trade workers	10.7
Plant and machine operators	9.5
Elementary occupations	18.4
Armed forces	5.9
Houseman / Unemployed	11.8
Retired	7.6
Dietary preference of HH members >1 year (n=7670)	
Non vegetarian	97.8
Ovo-vegetarian	0.5
Lacto-vegetarian	1.2
Vegan	0.5
Activity levels of HH members ≥10 years of age (n=6844)	
Sedentary	54.5
Moderately active	37.3
Heavily active	8.2

Table 3. Nutrition status of eligible participants

Age groups in years	*% (95% confidence interval)*				*No*
	Stunting	*Wasting / thinness*	*Overweight*	*Obesity*	
Children aged 1-4					
Male	18.8 (13.9-23.7)	13.1 (8.8-17.3)	1.6 (0.0-3.2)	*	245
Female	13.7 (9.4-18.0)	14.9 (10.4-19.4)	0.0	*	241
Both	16.3 (13.0-19.5)	14.0 (10.9-17.1)	0.8 (0.0-1.6)	*	486
Children aged 5-9					
Male	8.0 (4.4-11.7)	21.2 (15.7-26.7)	4.7 (1.9-4.6)	5.2 (1.9-7.6)	212
Female	9.1 (4.8-13.3)	21.6 (15.5-27.7)	5.7 (2.3-9.1)	5.1 (2.3-9.1)	176
Both	8.5 (5.7-11.3)	21.4 (17.3-25.5)	5.2 (3.0-7.4)	5.1 (3.0-7.4)	388
Children aged 10-17					
Male	16.8 (10.1-21.4)	24.2 (16.7-29.8)	13.0** (7.9-18.5)	6.8 (2.9-10.9)	161
Female	11.9 (6.9-15.9)	18.6 (12.7-23.6)	9.3 (5.2-13.4)	9.3 (5.2-13.5)	194
Both	14.1 (9.8-16.9)	21.1 (16.2-24.7)	11.0 (7.8-14.4)	8.2 (5.4-11.1)	355
Adults 18-60					
Male	0.7 (0.1-2.0)	9.3 (6.5-12.0)	30.2 (25.8-34.5)	5.6*** (3.4-7.7)	431
Female	6.8 (5.5-8.3)	10.1 (8.5-11.8)	33.4 (30.9-36.0)	13.4 (11.5-15.2)	1331
Both	5.4 (4.4-6.6)	9.9 (8.5-11.3)	32.6 (30.4-34.8)	11.5 (10.0-13.0)	1762

(*overweight and obesity accounted together due to low percentages; ** P<0.05; ***P<0.001)

Among children aged 1-4 years, wasting was not associated with the dietary intake. Stunting was significantly associated with the low calcium, iron and riboflavin intakes. Thinness of children aged 5-9 years was significantly associated with the low iron, niacin and folate intakes while stunting was associated with low protein and selenium intakes (Table 7).

Among children aged 10-17 years, thinness and stunting was not associated with dietary intakes, may be due to low sample sizes. In adults, thinness was significantly associated with low intakes of zinc, riboflavin and pantothenic acid. Overweight adults had significant relationship with higher intake of zinc, calcium, B_6 and folate while obesity was significantly associated with low iron intakes.

Table 4. Median daily intake of macronutrients and fibre in different age groups

Daily intake*	*Children aged 1-4 years*		*Children aged 5-9 years*		*Children aged 10-17 years*		*Adults 18-60 years*	
	Median (10^{th}-90^{th} percentile)	*% of adequate intake*	*Median (10^{th}-90^{th} percentile)*	*% of adequate intake*	*Median (10^{th}-90^{th} percentile)*	*% of adequate intake*	*Median (10^{th}-90^{th} percentile)*	*% of adequate intake*
Energy (kcal)	1057.8 (667.0-1659.8)	96.9	1386.7 (873.3-2070.2)	86.1	1794.2 (1166.7-3607.0)	82.0	1902.0 (1204.8-2908.1)	83.9
Protein (g)	32.1 (18.6-57.6)	119.7	41.8 (24.9-69.9)	121.3	53.4 (31.0-88.4)	88.6	58.1 (34.8-97.8)	118.5
% of calories from protein	12.1		12.1		11.9		12.2	
Total Fat (g)	28.1 (15.1-50.3)	**	34.4 (19.5-63.6)	**	42.4 (24.4-80.2)	**	46.6 (23.8-87.3)	**
% of calories from fat	23.9	60.0	22.3	55.8	21.3	60.9	22.1	63.1
Carbohydrate (g)	160.2 (99.3-264.7)	**	217.3 (136.7-327.2)	**	283.6 (183.4-421.4)	**	301.6 (187.7-471.0)	**
% of calories from carbohydrate	60.6	101.0	62.7	104.5	63.2	105.3	63.4	105.7
Total dietary fibre (g)	15.1 (8.7-25.2)	151.0	19.2 (11.7-34.0)	119.4	26.3 (16.0-43.9)	136.8	27.4 (16.3-46.1)	126.8
Soluble dietary fibre (g)	3.0 (1.8-5.2)	**	4.0 (2.5-6.6)	**	5.3 (3.2-8.4)	**	5.7 (3.2-9.3)	**
Insoluble dietary fibre (g)	11.7 (6.7-19.5)	**	15.2 (9.0-27.1)	**	19.9 (12.0-33.3)	**	21.2 (12.0-36.5)	**

(*There was no significant difference of daily intakes of nutrients between males and females; **AR or RI was not available to calculate adequacy)

(Percentage of calories from carbohydrate = median intake of carbohydrate in grams × 4 kcal/median energy intake kcal *100)

(Percentage of calories from fat = median intake of fat in grams × 9 kcal/median energy intake kcal *100)

Table 5. Median daily intake of vitamins in different age groups

Daily intake	*Children aged 1-4 years*		*Children aged 5-9 years*		*Children aged 10-17 years*		*Adults 18-60 years*	
	Median (10^{th}-90^{th} percentile)	*% of adequate intake*	*Median (10^{th}-90^{th} percentile)*	*% of adequate intake*	*Median (10^{th}-90^{th} percentile)*	*% of adequate intake*	*Median (10^{th}-90^{th} percentile)*	*% of adequate intake*
Vit A µg	118.3 (29.0-577.2)	28.3	149.0 (41.0-634.8)	30.1	218.3 (51.0-877.5)	39.0	212.1 (52.7-953.6)	39.3
Thiamine mg	0.2 (0.1-0.4)	28.8	0.2 (0.1-0.4)	23.5	0.2 (0.1-0.8)	21.8	0.3 (0.1-0.7)	24.9
Riboflavin mg	0.3 (0.1- 0.5)	51.6	0.4 (0.2-0.7)	45.4	0.5 (0.2-0.9)	44.6	0.5 (0.3-1.0)	48.5
Niacin mg	4.1 (2.1-8.7)	62.1	5.6 (2.9-11.3)	47.9	7.0 (3.8-15.7)	44.4	7.6 (4.1-15.4)	51.2
Vit B_6 mg	0.5 (0.3-1.1)	99.6	0.7 (0.4-1.4)	77.4	0.9 (0.5-1.9)	74.4	1.0 (0.5-1.9)	72.8
Vit B_{12} µg	1.6 (0.0-7.9)	159.3	2.3 (0.0-8.4)	123.4	2.5 (0.0-9.1)	104.4	3.0 (2.0-5.6)	123.7
Pantothenic acid mg	2.0 (1.1-3.2)	83.4	2.6 (1.6-4.1)	65.3	3.3 (1.9-5.4)	66.8	3.5 (2.0-5.6)	69.3
Folate µg	76.7 (38.5-157.9)	42.3	103.1 (56.6-207.7)	36.4	129.0 (65.2-266.8)	33.7	138.3 (72.1-281.4)	34.0
Vit C mg	15.6 (4.0-41.0)	50.5	24.4 (6.5-66.6)	72.9	29.2 (6.5-82.5)	70.7	28.4 (8.3-104.2)	45.0

(There was no significant difference of intakes of nutrients between males and females)

Table 6. Median daily intake of minerals in different age groups

Daily intake	*Children aged 1-4 years*		*Children aged 5-9 years*		*Children aged 10-17 years*		*Adults 18-60 years*	
	Median (10^{th}-90^{th} percentile)	*% of adequate intake*	*Median (10^{th}-90^{th} percentile)*	*% of adequate intake*	*Median (10^{th}-90^{th} percentile)*	*% of adequate intake*	*Median (10^{th}-90^{th} percentile)*	*% of adequate intake*
Calcium mg	166.8 (54.7-375.4)	31.8	216.0 (94.5-449.0)	32.8	269.6 (122.0-552.9)	29.0	306.8 (130.9-649.7)	41.6
Iron mg	5.7 (3.4-10.1)	87.9	7.6 (4.3-13.0)	85.3	9.7 (5.3-17.0)	56.5	10.5 (5.9-18.5)	42.2
Zinc mg	4.6 (2.9-8.2)	108.7	6.0 (3.7-9.9)	108.9	7.8 (5.2-12.0)	106.3	8.5 (5.1-13.8)	152.3
Selenium µg	69.3 (32.5-168.5)	378.6	96.7 (46.1-215.9)	445.3	116.8 (59.3-256.6)	400.1	125.7 (62.5-289.3)	447.7
Magnesium mg	138.7 (79.1-230.0)	204.2	174.5 (106.4-307.5)	174.1	224.0 (137.9-389.8)	105.8	245.4 (147.4-424.0)	108.8
Iodine µg	73.0 (32.8-167.6)	86.6	95.6 (43.0-181.9)	95.1	110.8 (54.9-237.7)	98.4	128.1 (61.0-265.1)	109.2

(There was no significant difference of intakes of nutrients between males and females)

Table 7. Median adequacy level of each nutrient in relation to the presence or absence of wasting/thinness, stunting and overweight/obesity of different age groups

		Children aged 1-4 years		*Children aged 5-9 years*		*Children aged 10-17 years*		*Adults 18-60 years*		
Daily intake		*Wasting*	*Stunting*	*Thinness*	*Stunting*	*Thinness*	*Stunting*	*Thinness*	*Overweight*	*Obese*
Energy (kcal)	Yes	91.7	84.6	84.6	83.0	88.1	83.0	79.9	85.1	84.8
	No	97.3	98.3	86.5	81.8	80.8	81.8	84.4	83.8	83.9
Protein (g)	Yes	119.8	109.1	109.2	79.9**	93.9	79.9	115.0	120.2	121.0
	No	119.8	121.4	124.8	89.1	88.0	89.1	118.8	117.8	118.1
Calcium mg	Yes	26.4	23.2**	29.6	24.8	30.0	24.8	38.0	44.5	36.3
	No	32.8	32.8	33.9	29.4	62.7	29.4	42.4	40.5	42.4
Iron mg	Yes	82.4	78.7**	77.0**	48.6	62.7	48.6	39.1	41.3	35.1**
	No	88.8	89.1	88.1	60.0	56.2	60.0	42.5	42.8	42.9
Zinc mg	Yes	97.1	112.0	100.8	117.3	104.6	117.3	140.3**	156.1*	150.3
	No	109.2	109.3	113.1	104.3	106.8	104.3	153.4	150.2	152.4
Selenium µg	Yes	377.3	322.7	380.0	358.6*	408.6	358.6	451.9	457.6	476.3
	No	378.3	381.2	449.5	409.3	397.8	409.3	447.9	446.3	446.5
Magnesium mg	Yes	197.2	169.9	160.6	105.4	105.9	105.4	103.6	110.2	108.4
	No	205.2	206.8	177.1	106.4	106.4	106.4	109.8	108.2	108.9
Iodine µg	Yes	91.7	75.7	87.2	93.7	107.6	93.7	105.0	111.6	112.3
	No	86.6	88.1	96.4	98.5	93.8	98.5	109.9	107.9	109.5
Vit A µg	Yes	24.2	45.9	23.6	43.8	47.0	43.8	28.6	37.7	38.2
	No	29.1	26.6	35.0	38.5	36.0	38.5	40.9	40.9	40.0
Thiamine mg	Yes	22.5	24.3	22.1	22.1	26.5	22.1	25.7	24.3	22.4
	No	29.5	29.4	24.7	21.7	19.3	21.7	24.8	25.1	25.1
Riboflavin mg	Yes	42.7	47.9**	44.0	45.1	45.2	45.1	42.3**	48.9	49.9
	No	54.1	51.8	46.5	45.0	44.7	45.0	48.6	47.6	48.3
Niacin mg	Yes	49.4	61.0	41.2*	46.2**	45.3	46.2	49.8	52.5	51.8
	No	63.0	62.2	49.2	44.4	44.3	44.4	51.5	50.8	51.1
Vit B_6 mg	Yes	84.9	101.2	73.6	81.5*	80.2	81.5	68.1	77.2*	71.7
	No	100.6	97.9	77.6	74.5	73.8	74.5	73.1	69.7	72.8
Vit B_{12} µg	Yes	42.4	161.2**	108.0	75.6	67.8	75.6	120.9	130.9	130.9
	No	172.0	159.3	124.2	105.0	116.0	105.0	123.1	117.9	120.7
Pantothenic acid mg	Yes	73.5	83.5	56.9	69.1	74.8	69.1	66.3*	69.5	65.5
	No	83.8	83.4	67.7	66.8	66.1	66.8	69.8	68.5	69.5
Folate µg	Yes	36.5	42.7	32.0*	30.2	33.9	30.2	32.9	36.0*	31.8
	No	42.6	42.1	37.2	34.2	33.6	34.2	34.3	33.4	34.1
Vit C mg	Yes	50.2	46.1	66.2	82.1	67.1	82.1	45.5	45.7	41.3
	No	51.0	51.0	74.0	71.0	72.0	71.0	44.8	44.4	45.8

*P<0.05; **P<0.01)

Discussion

This is the first national study conducted to assess nutritional status, macronutrients and micronutrients intakes of Sri Lankans aged 1-60 years using Sri Lankan food composition data and Average Requirements (AR) for Sri Lankans. Among a nationally representative sample of households across the Sri Lanka, Double Burden of Malnutrition (DBM), both wasting/thinness and overweight, is prevalent in all categories of age groups. The past 24-hour recall of dietary consumption indicated micronutrient gaps in the diet, confirming the Triple Burden of Malnutrition (TBM) in Sri Lanka.

The median dietary intake of vitamin A, thiamine, riboflavin, niacin, folate, vitamin C, calcium, iron and iodine are lower than the AR while energy, protein and zinc intakes are adequate in children aged 1-4 years. Furthermore, low intakes of calcium, iron, riboflavin is significantly associated with stunting. Wasting is not associated with macro and micronutrient intakes. A previous study conducted among children aged 3-5 years showed that folate and zinc were inadequate and other macro and micronutrients intakes were satisfactory [19]. Adequate micronutrient intake is detrimental to the growth of children at this age. This may indirectly explain the 16% of stunting and 14% wasting in this age group. However, there is a slight improvement of wasting and stunting compared to 2016 DHS data among children under five years [3].

Our findings on children aged 5-9 years of age showed that low intakes of iron, niacin and folate are significantly associated with thinness while low intakes of protein, niacin and vitamin B_6 are significantly associated with stunting. Overall energy and many micronutrient intakes are below the AR. It reflects with the 9% of stunting, 21% of thinness, 5% of overweight and 5% of obesity among them. However, nutritional status is improved over time, it was 11.5%, 30.2%, 6.1% respectively in 2016 while obesity has increased from 2.9% to 5.1% [20]. Furthermore, the present study showed there is a significantly low protein intake among stunted children aged 5-9 years. This should be addressed urgently before they reach the pubertal spurt to achieve the optimum height.

Present study shows a remarkable improvement of energy (1794 Vs 1195 kcal), protein (54 Vs 28g), fat (42 Vs 4.3 g) and zinc (8 Vs 0.7mg) intakes of children aged 10-17 years in comparison to the study conducted in 2003 [21]. However, intakes of iron are not improved, which fulfil only 57% of AR. Calcium intake is lowest in this age group, which fulfil only 29% of AR. Overall energy (82%), protein (89%), vitamin A (39%), B vitamins (22-74%) and vitamin C (71%) intakes were far below the AR. This may reflect the increase of stunting in adolescents from 13.7% in 2016 to 14.1% in the present study [22]. Low intakes of macro and micronutrients will affect the optimum growth during adolescence and can put adolescent girls at greater risk during later pregnancy.

Our findings indicated among adults, 63.4% of energy came from carbohydrates, which is higher than the recommended level of 45-60% of energy. Protein and fat intakes are 12.2% and 22.1%, which are within the recommended level of 10-15% and 20-30% energy respectively. There is an improvement of dietary consumption compared to the previous study, which showed 71.2% energy came from carbohydrates among Sri Lankan adults, 10.8% from protein and 18.9% from fat [23]. Overall, energy, protein and fibre intakes were higher than in 2014 (1902 Vs 1514 kcal; 58.1 Vs 44.6 g and 27.4 Vs 18.1 g respectively).

Dietary intake of calcium, iron, vitamin A, thiamin, riboflavin, niacin, pantothenic acid, folate and vitamin C were far below the AR of all the age groups. It indirectly indicates the less diversity of diet consumed by all the members at household level, which was inadequate to fulfil the daily needs of many micronutrients. Many of the shortfall nutrients in our analysis is similar to the findings of other studies [17,24,25,26,27]. The most salient feature of our study is over 300% AR of selenium in the diet of all age groups, contributed from many spices used for cooking. However, the 90th percentile is just below the upper intake level of 300 µg/day indicating no excess intake [5].

The main strength of the study is 24-hour recall was taken from the person most often responsible for managing kitchen, cooking and serving household members.

The interpretation of our findings is subject to several limitations. First, the prevalent of TBM and dietary consumption cannot be fully explained because the data are cross-sectional. Second, the changing lifestyle during the covid pandemic could have influenced the results. For example, 55% of sedentary lifestyle may be important predictor of TBM. They could also be associated with access and economic status during covid pandemics due to repeated lock downs. Third, the poverty and food insecurity data were not included.

Conclusions

High intakes of carbohydrate and protein while low intakes of calcium, iron, vitamin A, B vitamins and vitamin C was reported in all age groups, and may be due to access issues related to covid pandemics and many lockdowns. Our results suggest that dietary intake have no direct influence on wasting of children aged 1-4 years in Sri Lanka. In conclusions, it confirms the presence of DBM in children and adults at household, community and population levels in Sri Lanka. Usual daily diets are not sufficient to fulfil many essential micronutrients and lead to TBM. Programmes such as supplementation, fortification of staple foods should be targeted to assist households to access sufficient, high quality, and nutrient-rich food to overcome TBM in Sri Lanka. In investing on nutrition policy, one size fit interventions need to be implemented to combat TBM. Therefore, strategizing and

redesigning public health nutrition programmes following the COVID-19 pandemic is the priority in Sri Lanka.

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Author contributions

Renuka Jayatissa conceptualised, designed, analysed data and wrote the paper. Ranbanda Jayawardana, Amila Perera, Nawmali De Alwis, Devisri Abeysingha, KH De Silva and Wasana Marasinghe conducted the national survey, helped to analyse the data set and assist to write the paper. All authors read the manuscript, made a substantial contribution to the revision and approved the final manuscript.

Conflicts of interest

The opinions expressed are those of the authors do not necessarily reflect the views of the institutions that they are affiliated with. The Authors declare that there is no conflict of interest.

References

1. World Health Organisation. Childhood malnutrition in Sri Lanka: a road map for the last mile: A review of literature, analysis of correlates of undernutrition, a qualitative inquiry. Colombo: 2019. https://apps.who.int/iris/bitstream/handle/10665/342173/9789290227847-eng.pdf (accessed April 2023).
2. Christian AK, Dake FA. Profiling household double and triple burden of malnutrition in sub-Saharan Africa: prevalence and influencing household factors. *Public Health Nutr.* 2022; **25**(6): 1563-76.
3. Department of Census and Statistics, Ministry of National Policies and Economic Affairs (2017) Sri Lanka Demographic and Health Survey 2016. Health Sector Development Project Ministry of Health, *Nutrition and Indigenous Medicine*. http://www.statistics.gov.lk (accessed April 2023).
4. World Health Organisation (2016) The double burden of malnutrition. Policy brief. WHO-https://NMH-NHD-17.3-eng.pdf (accessed April 2023).
5. Jayatissa R, Herath HP, Perera AG, Dayaratne TT, De Alwis ND, Nanayakkara HPLK. Impact of COVID-19 on child malnutrition, obesity in women and household food insecurity in underserved urban settlements in Sri Lanka: a prospective follow-up study. *Public Health Nutr*. 2021; **24**(11): 3233-41.
6. World Health Organization. Triple billion targets. 2020. https://www.who.int/news-room/questions-and-answers/item/the-triple-billion-targets (accessed April 2023).
7. FAO. 2018. Dietary Assessment: A resource guide to method selection and application in low resource settings. Rome.
8. EFSA (European Food Safety Authority), 2013. Standard Sample Description ver. 2.0. *EFSA Journal* 2013; **11**(10): 3424, 114 pp.
9. Medical Research Institute. Dietary reference intakes for Sri Lankans. Department of Nutrition. Colombo 2022.
10. Jayatissa R, Perera AG, Silva ABG, Amarathunga YN, De Alwis ND, Ananthan A, Longvah T. Sri Lanka food composition table. 2nd Edition. Colombo; 2021.
11. European Food Safety Authority, 2015. The food classification and description system FoodEx2 (revision 2). EFSA supporting publication 2015:EN-804. 90 pp.
12. EFSA (European Food Safety Authority), 2011a. Report on the development of a food classification and description system for exposure assessment and guidance on its implementation and use. *EFSA Journal* 2011; **9**(12): 2489, 84 pp.
13. EFSA (European Food Safety Authority), 2011b. The food classification and description system FoodEx 2 (draft revision 1). Supporting Publications 2011:215, 438 pp. Available online: http://www.efsa.europa.eu/en/supporting/doc/215e.pdf
14. World Health Organisation. Physical Status: The Use and Interpretation of Anthropometry; WHO: Geneva, Switzerland 1995.
15. World Health Organisation. WHO AnthroPlus for personal computers Manual: Software for assessing growth of the world's children and adolescents. Geneva: WHO, 2009 (http://www.who.int/growthref/tools/en/).
16. Ministry of women and child development. Nutrition surveys in India. 2017. http://www.nutrition-surveys-in-india-ministry-of-women-and-child-development
17. Singh A, Gupta V, Ghosh A. *et al*. Quantitative estimates of dietary intake with special emphasis on snacking pattern and nutritional status of free living adults in urban slums of Delhi: impact of nutrition transition. *BMC Nutr. 2015;* **1**: 22. https://doi.org/10.1186/s40795-015-0018-6
18. Bailey ADL, Fulgoni Iii VL, Shah N, Patterson AC, Gutierrez-Orozco F, Mathews RS, Walsh KR. Nutrient Intake Adequacy from Food and Beverage Intake of US Children Aged 1-6 Years from NHANES 2001-2016. *Nutrients* 2021; **13**(3): 827. doi: 10.3390/nu13030827. PMID: 33802295; PMCID: PMC8002201.
19. Hettiarachchi M, Liyanage C. Dietary macro- and micro-nutrient intake among a cohort of pre-school children from southern Sri Lanka. *Ceylon Medical Journal* 2010; **55**(2): 47-52. DOI: 1989-7050-1-PB.pdf
20. Jayatissa R, Fernando DN, Herath H. Nutritional status, dietary practices and pattern of physical activity among

schoolchildren aged 6-12 years 2016. Medical Research Institute. Ministry of Health. 2017.

21. Hettiarachchi M, Liyanage C, Wickremasinghe R, Abrama SA. Nutrient intake and growth of adolescents in southern Sri Lanka. *Ceylon Medical Journal* 2006; **51**(3): 89-92. DOI: 10.4038/cmj.v51i3.1249

22. Jayatissa R, Fernando DN, Perera A, De Alwis N. National Nutrition and micronutrient survey among school adolescents aged 10-18 years in Sri Lanka. 2017. Medical Research Institute. Ministry of Health. Colombo. 2019.

23. Jayawardena R, Thennakoon S, Byrne N, Soares M, Katulanda P, Hills A. Energy and nutrient intakes among Sri Lankan adults. *Int Arch Med*. 2014; **7**: 34. doi: 10.1186/1755-7682-7-34.

24. Bermudez OI, Lividini K, Smitz MF, Fiedler JL. Estimating micronutrient intakes from Household Consumption and Expenditures Surveys (HCES): an example from Bangladesh. *Food Nutr Bull*. 2012; **33**(3 Suppl): S208-13. doi: 10.1177/15648265120333S209. PMID: 23193772.

25. Akter R, Sugino H, Akhter N, Brown CL, Thilsted SH, Yagi N. Micronutrient Adequacy in the Diet of Reproductive-Aged Adolescent Girls and Adult Women in Rural Bangladesh. *Nutrients* 2021; **13**(2): 337. doi: 10.3390/nu13020337. PMID: 33498750; PMCID: PMC7911270.

26. Puwanant M, Boonrusmee S, Jaruratanasirikul S, *et al*. Dietary diversity and micronutrient adequacy among women of reproductive age: a cross-sectional study in Southern Thailand. *BMC Nutr.* 2022; **8**: 127. https://doi.org/10.1186/s40795-022-00619-3

27. Ito T, Tanisawa K, Kawakami R, Usui C, Ishii K, Suzuki K, Sakamoto S, Muraoka I, Oka K, Higuchi M. Micronutrient Intake Adequacy in Men and Women with a Healthy Japanese Dietary Pattern. *Nutrients* 2020; **12**: 6. https://doi.org/10.3390/nu12010006