National Nutrition and Micronutrient Survey in Sri Lanka: 2022

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partnership with

UNICEF and WFP

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A special thanks goes to the dedicated staff of the Department of Nutrition, Medical Research institute, who coordinated and collected data on time.

Finally, we would like to thank all the participants of this research.

Dr. Renuka Jayatissa

Principal Investigator
Head, Department of Nutrition
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MESSAGE FROM THE SECRETARY, MINISTRY OF HEALTH

Good Health and wellbeing of the citizens is an important factor of the development of a country. Nutrition status is one of the key elements which determine good health. Consumption of good, nutritious meals provides an adequate number of macronutrients and micronutrients which help to maintain good health.

Therefore, regular assessment of the nutrition and micronutrient status in different age groups of the population is important to identify the deficiencies, insufficiencies, or sufficiency of different macro and micronutrients.

National Nutrition and Micronutrient Survey in Sri Lanka - 2022 was conducted by the Department of Nutrition, Medical Research Institute, Colombo at the right time for country to plan and develop the health policies and guidelines to improve the nutrition and micronutrient status of Sri Lankans during this economic crisis period.

I would like to thank the World Food Programme and UNICEF for their partnership with the Ministry of Health to conduct this research.

I would like to congratulate the Department of Nutrition, Medical Research Institute for conducting this research and releasing data within a short period of time to facilitate the future nutrition programmes during the needy period.

I hope that the findings of this research will help to uplift the nutrition and micronutrient status of the citizens of Sri Lanka.

Mr. S. Janaka Sri Chandraguptha

Secretary
Ministry of Health

MESSAGE FROM THE DIRECTOR, MEDICAL RESEARCH INSTITUTE

It is important to assess the nutrition and micronutrient status of the citizens of the country regularly, as it reflects the outcomes of existing intervention programmes and to plan further interventions to improve the good health of the citizens.

I would like to congratulate the Department of Nutrition for completing this national research successfully. I highly appreciate the dedicated staff of the Department of Nutrition at the Medical Research Institute for their hard work for completing the research on time. It is my pleasure to pay my gratitude to UNICEF and WFP for their successful partnership to accomplish this huge task.

This study provides current nutritional status and micronutrient status of the population as well as food security status of the households in Sri Lanka. The findings of this study will be useful for policy makers to plan the necessary activities to improve the nutrition and micronutrient status of different age groups and to improve the food security at household level in Sri Lanka during this period of economic crisis.

I hope the findings of this study will be used to improve nutrition services to provide evidence-based interventions to improve the nutrition status and good health of the citizens of the country.

Dr Dedunu Dias

Director
Medical Research Institute

MESSAGE FROM THE UNICEF REPRESENTATIVE

The issue of nutrition in Sri Lanka has never been more important than today. The country has been facing the double burden of malnutrition over the past few decades, characterized by coexistence of undernutrition along with overweight, obesity, or diet related non-communicable diseases (NCDs). Many of the nutrition-sensitive and nutrition-specific interventions are included in the national programmes, with the objective of improving the nutrition and micronutrient status of different age groups. There is now a need to assess the nutrition and micronutrient status in different age groups to identify the status of micronutrients, level of existing public health problems and risk of developing public health problems for each specific age group. This critical information would enable improvements in the current interventions and introduce new interventions if required.

UNICEF is pleased to have provided technical and financial support to this very important research project. We highly appreciate the commitment of the Ministry of Health, and especially Principal Investigator, Dr Renuka Jayatissa, Consultant Medical Nutritionist and Head of the Department of Nutrition of Medical Research Institute of the Ministry of Health and her research team in producing this extremely useful report with its pertinent recommendations to address critical micronutrient deficiencies across the life cycle. We hope the report, its findings and recommendations would help sharpen the ongoing efforts to strengthen nutrition related policies and programmes and the nutrition reporting and surveillance system; and ultimately improve the nutritional status of every person in Sri Lanka.

Christian Skoog

Representative
UNICEF Sri Lanka

MESSAGE FROM THE UNITED NATIONS WORLD FOOD PROGRAMME COUNTRY DIRECTOR

A healthy nation is critical to help restore Sri Lanka's economy and set it back on the path to recovery. The on-going economic crisis, coupled with the lingering effects of the COVID-19 pandemic is not only compromising people's ability to access regular, healthy meals but threatening a spike in the number of malnourished people. As we work towards rebuilding our nation, it is important for all decision makers and stakeholders to have access to updated information which will help prepare appropriate responses to safeguard those most at risk of malnutrition.

The United Nations World Food Programme (WFP) has consistently prioritized nutrition as a core element of our work. We are honored to have joined hands with our sister UN agency UNICEF to work with the Medical Research Institute of the Ministry of Health to conduct the National Nutrition and Micronutrient Survey in Sri Lanka, 2022. This survey is one among many that WFP has contributed to over the years, as part of our on-going support to the Government.

We are pleased that the country not only has an updated overview of nutrition but also possesses disaggregated data which analyses nutrition across gender, age, and region. We are confident that the findings will be useful for diverse actors to help them in planning and implementing appropriate responses to address malnutrition in the country. The findings will be particularly useful to policy makers and program planners to make informed decisions at the national and decentralized levels.

WFP remains committed to supporting the Government and people of Sri Lanka to build a healthy and prosperous nation in which everyone has access to safe and nutritious food.

Abdur Rahim Siddiqui

Representative and Country Director
United Nations World Food Programme, Sri Lanka

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SUMMARY

Micronutrition deficiencies are important public health problems in Sri Lanka. Based on available data suitable interventions have been implemented at national level. However, recent data on important micronutrient deficiencies are limited. Hence the need for a comprehensive assessment of the micronutrient status of vulnerable groups was considered as a priority. The objectives of this assessment were to determine the prevalence of anaemia, iron deficiency, iron deficiency anaemia, vitamin A deficiency, vitamin D deficiency, vitamin B_{12} deficiency, folic acid deficiency and zinc deficiency among different age categories of population groups in households including pregnant women; to determine the provincial level prevalence of wasting / thinness / underweight, stunting, overweight and obesity among them; to assess the household food security and to determine the coverage of nutrition interventions.

Results of major components of the study are presented in this report, findings on vitamin A deficiency and folic acid deficiency will be presented later.

The study was carried out in a representative sample of 2936 households from the 25 districts of Sri Lanka identified using a multistage cluster sampling procedure. Households were listed in each cluster, altogether 105 clusters were included. The study population included children aged 6 months to 17 years, adult women and men aged 18-60 years, elderly >60 years and pregnant women resident in the selected households. Pregnant women were also included from the antenatal clinics conducted within the cluster to fulfil the sample. The field level data collection was carried out using a pretested interviewer administered questionnaire, taking relevant anthropometric measurements, and collecting venous blood samples for the biochemical assessments. All precautions were taken to ensure the quality of data.

Average number of members in the selected household were 4.2 ± 1.4 with a majority had 4-5 members. Median household income was Rs. 40,000 (25^{th} to 75^{th} percentile: 25,000 – 60,000). Half of mothers were educated up to grade 11.

Prevalence of stunting, wasting, underweight and overweight/obesity among children 6–59 months of age were 13.7, 19.8, 22.7 and 1.7 percent, respectively. Severe acute malnutrition (SAM) was present in 2.5% of the total sample. Stunting was low during the latter half of the first year of life and highest during the second year while the prevalence of wasting showed a consistent increase up to 48-59 months. Stunting and wasting was higher among boys.

Among children aged 6-59 months, comparison of prevalence between provinces showed that prevalence of stunting ranged from 6.2% in Eastern province to 21.5% in Central province with six provinces having prevalence at higher levels compared to the 'national prevalence'. Prevalence of wasting ranged from 12.1% in Sabaragamuwa province to 27.1% in Northwestern province with six provinces showing higher prevalence figures compared to the 'national prevalence.' Prevalence of underweight ranged from 18.5% in Sabaragamuwa province to 38.0% in Northwestern province with three provinces showing higher prevalence figures compared to the 'national prevalence.' Prevalence of overweight/obesity children was highest in Western province (3.3%). Highest prevalence of stunting was observed in the estate sector (33.1%) while the highest wasting prevalence was found in the urban sector (22.0%).

From the total sample of children aged 6-59 months, haemoglobin (Hb) estimations were done among 1210 children. Of this group, 14.6% were anaemic (Hb level <11 gms/dL) and higher in female children. There is a consistent decreasing pattern of anaemia with increasing age, showing the highest prevalence of 30% in the age group of 6-11 months. Inter provincial

comparisons show the prevalence to range between a low value of 8.3% in Eastern province to 20.6% in Northcentral province. Prevalence of iron deficiency, iron deficiency anaemia, vitamin D deficiency and zinc deficiency was 5.4%, 1.8%, 26.2% and 15.3% respectively. Median urinary iodine concentration was 93.8 µg/L, which is below the optimum level of 100 µg/L.

Prevalence of stunting, wasting/thin, overweight and obesity among children aged 5-9 years were 7.8, 25.8, 4.1 and 2.6 percent, respectively. Stunting was highest in females (9.4%). Wasting was higher among boys than girls. From the total sample, haemoglobin (Hb) estimations were done among 636 children aged 5-9 years. Of this group, 10.2% were anaemic (Hb level <11.5 gms/dl) and higher in girls than boys (10.5 Vs 9.9%). The highest prevalence of 11.5% was observed in the age group of 5-6.9 years and children from the urban sector (10.5%). Prevalence of iron deficiency, iron deficiency anaemia, vitamin D deficiency, vitamin B_{12} deficiency and zinc deficiency was 7.6%, 0.6%, 23.9%, 1.7% and 17.0% respectively. Median urinary iodine concentration was 101.0 µg/L, which is just above the optimum level of 100 µg/L.

Prevalence of stunting, wasting/thin, overweight and obesity among children 10-17 years were 16.5, 25.2, 7.9 and 4.0 percent, respectively. Stunting and wasting was highest during the 14-17 years age group. Wasting was higher among boys than girls. From the total sample, haemoglobin (Hb) estimations were done among 468 children aged 10-17 years. Of this group, 18.3% were anaemic and higher in boys than girls. The highest prevalence of anaemia was 27.7% in the age group of 14-17 years. Inter sectoral comparisons show the prevalence to range between a low value of 18.0% in the rural sector to 20.0% in urban sector. Prevalence of iron deficiency and iron deficiency anaemia was 5.0% and 2.2% respectively. Median urinary iodine concentration was 90.5 µg/L, which is below the optimum level of 100 µg/L.

Prevalence of underweight/thin, overweight and obesity among pregnant women during the first trimester were 14.2, 27.4 and 5.3 percent, respectively. From the total sample, haemoglobin (Hb) estimations were done among 1086 pregnant women. Of this group, 15.0% were anaemic and higher during the third trimester. The highest prevalence of 17.7% in the age group >35 years. Inter provincial comparisons show the prevalence of anaemia to range between a low value of 8.3% in Sabaragamuwa province to 22.4% in Northcentral province. Prevalence of iron deficiency, iron deficiency anaemia, vitamin D deficiency, zinc deficiency and vitamin B_{12} deficiency was 11.0%, 2.5%, 35.6%, 24.5% and 16.6% respectively. Median urinary iodine concentration was 77.2 µg/L, which is below the optimum level of 150 µg/L.

Among non-pregnant adult women aged 18-60 years living in selected households show that prevalence of underweight/thinness ranged from 20.5% to 6.3%, higher values among younger women. However, prevalence of overweight (34.0%) and obesity (17.8%) especially among the older age groups seem to be emerging nutritional problems. Inter provincial comparisons show the prevalence of obesity to range between a low value of 8.6% in Southern province to 17.2% in Western province. From the total sample, haemoglobin (Hb) estimations were done among 1518 non pregnant adult women. Of this group, 18.5% were anaemic. The highest prevalence of 26.7% was found in the age group of 40-49 years. Inter provincial comparisons show the prevalence of anaemia to range between a low value of 10.9% in Eastern province to 24.0% in Northwestern province. Prevalence of iron deficiency and iron deficiency anaemia was 7.2% and 3.2% respectively. Median urinary iodine concentration was 78.1 µg/L, which is below the optimum level of 100 µg/L.

Among the adult males, prevalence of underweight/thinness was 10.7% while the prevalence of overweight and obesity was 25.6% and 6.4% respectively. These prevalences are lower in compared to women. Inter provincial comparisons show the prevalence of obesity to range

between a low value of 0.0% in Uva province to 13.4% in Northern province. From the total sample, haemoglobin (Hb) estimations were done among 768 men. Of this group, 8.2% were anaemic. The highest prevalence of 11.4% in the >40 years of age. Inter provincial comparisons show the prevalence of anaemia to range between a low value of 2.8% in Southern province to 18.2% in Eastern province. Prevalence of iron deficiency and iron deficiency anaemia was 2.5% and 0.4% respectively. Median urinary iodine concentration was 89.4 µg/L, which is below the optimum level of 100 µg/L.

Among the adults above 60 years of age, prevalence of underweight/thinness was 12.1% while the prevalence of overweight and obesity was 27.3% and 7.1% respectively. Underweight prevalence was higher in men and adults ≥ 70 years of age group while overweight and obesity prevalence were higher in women. Inter sectoral comparison shows the prevalence of underweight to range between a low value of 8.7% in estate sector to high value of 19.0% in urban sector. Median urinary iodine concentration was 67.3 µg/L, which is below the optimum level of 100 µg/L.

According to the Global Food Insecurity Experience Scale **(**FIES), at national level, 39.3% of households have moderate and severe food insecurity while 0.6% have severe food insecurity. Moderate and severe food insecurity ranged from 16.0% in Northern province to 48.7% in North central province.

The findings of this study indicate wasting of children aged 6-59 months is a critical public health problem. There is a need to address the high prevalence of wasting urgently. Appropriate interventions have to be implemented to minimise the disparities at provincial level. Overweight and obesity is an emerging public health problem among all the age groups including pregnant women during the first trimester.

In general, the iron levels in all population groups that studied could be considered as satisfactory, indicating that current interventions have been satisfactorily reached the population groups. However, this study also shows the relatively high prevalence of vitamin D deficiency in all studied age groups indicating the need for attention in improving vitamin D intake across the population. It was observed that zinc deficiency and vitamin B_{12} deficiencies are emerging micronutrient problems. Median urinary iodine concentrations were below the optimum levels in all age groups except children aged 5-9 years indicating an urgent necessity to revisit the salt iodisation programme in the country.

This study showed that factors other than iron deficiency are causes of anaemia in all age groups, especially zinc deficiency. In view of the ongoing preventive programmes focusing mainly on iron supplementation, it is necessary to review these programmes, which need to be supported by in-depth research on the causes of anaemia. The assessment of association between food intake and anaemia, zinc deficiency, vitamin B_{12} deficiency has to be studied, both in terms of food groups as well as the amount and pattern of intake. Inter provincial variations in anaemia, iron deficiency, zinc deficiency, vitamin D deficiency, vitamin B_{12} deficiency and other contributory factors to these deficiencies have to be taken into consideration in developing appropriate interventions at the provincial level.

It is further indicated there is a need to focus on household vulnerability mapping and to improve food and nutrition security among the population throughout the life stages at household level.

CHAPTER 1: INTRODUCTION

1.1 Background

Good nutrition has a life-changing potential. Lack of essential vitamins and minerals, or micronutrients, can have devastating consequences from birth to adulthood. The energy, protein, and micronutrient requirement of everyone depends on the age, sex, physiological status and the physical activities and it vary among the individuals at each household. The changes of the living style during the past few decades and the repeated lock down due to COVID-19 directly affected the food patterns of the citizens.

Micronutrient deficiencies ("hidden hunger") may be a more serious problem to consider than energy deficiency in Sri Lanka. Anaemia is associated with impaired physical and cognitive development in children, poor mental and physical performance in adults, increased risks of infectious diseases, and numerous other problems.

In a study conducted to assess the nutritional status of children and adults, it was found out that the prevalence of stunting, wasting and underweight among children 6–59 months of age were 13.1, 19.6 and 23.5 percent respectively. While stunting and wasting was higher among male children, a high prevalence of stunting, wasting and underweight was seen among the children whose fathers were employed in lower occupational categories.

Prevalence of thinness fluctuated from 14.9% to 36.7%, among non-pregnant adult women and it showed a higher value among younger women. Furthermore, the prevalence of overweight and obesity was observed to be an emerging nutritional problem. Among the adult males the prevalence of overweight and obesity was lower than in the adult females, while prevalence of thinness was 16.2%. [1]

Among a total of 547 children (aged 1–15 years, mean 7.0 ± 3.6 years, 53% female) in a study to assess the Nutritional status and correlated socio-economic factors among preschool and school children in plantation communities, Sri Lanka, 35.6%, 26.9% and 32.9% of children were underweight, stunted, and wasted respectively. While under nutrition was more common in primary school children, the associated factors were maternal employment, high number of siblings, high birth orders and female children. Among school children the associated factors for undernutrition were living in small houses, large number of family members, low monthly income, and maternal employment.[2]

In a study aimed to assess nutrition status, dietary diversity and lifestyle risk factors associated with under nutrition in an institutionalized Sri Lankan elderly population, 30% of the institutionalized elders were reported to be undernourished.[3]

Older age, lower monthly family income, low level of education and living in rural areas were found to be possible risk factors of malnutrition, in a study conducted in Galle district, Sri Lanka to evaluate the nutritional status of elders. The study showed that 0.5% elderly were malnourished and 30.8% were at risk of malnutrition.[4]

Thus, it is necessary to identify the basic problems and deficiencies related to the children and adults. Furthermore, it is important to evaluate the basic background, nutrition, and socio-economic information, which will be helpful for the policy makers to plan the necessary health promoting programmes.

In Sri Lanka, data on micronutrient deficiencies and coverage of interventions in recent years are limited. The need to make a national level assessment of the micronutrient status among all age groups in Sri Lanka was identified as a priority. Such data needs to be used in controlling micronutrient deficiencies and as a baseline for monitoring on-going nutrition intervention programmes aimed at such control. It is also important to identify the need for new interventions such as fortification of staple foods or commonly consumed foods with key micronutrients.

After consideration of the unavailability of recent data on the micronutrient status of children and adults, National nutrition steering committee chaired by the Secretary of Health identified a necessity of a study on the micronutrient status of women and children. This resulted in the decision to conduct a nation-wide study in Sri Lanka. This also helps to identify the gaps and excesses in existing nutrition programmes and helps to adjust or plan new intervention programmes (e.g.: food fortification/ supplementation) to optimise the nutritional status of the citizens.

1.2 Objectives

1. To determine the national level prevalence of wasting/thinness/underweight/stunting, overweight and obesity of

    a. Children aged 6-59 months
    b. Children aged 5-17 years
    c. Non pregnant women aged 18-60 years
    d. Pregnant women
    e. Men aged 18-60 years
    f. Adults above 60 years of age

2. To determine the national level prevalence of anaemia, iron deficiency, iron deficiency anaemia and iodine deficiency among

    a. Children aged 6-59 months
    b. Children aged 5-17 years
    c. Non pregnant women aged 18-60 years
    d. Pregnant women
    e. Men aged 18-60 years

3. To determine the national level prevalence of Vitamin D deficiency among

    a. Children aged 6-59 months
    b. Children aged 5-17 years
    c. Non pregnant women aged 18-60 years
    d. Pregnant women

4. To determine the national level prevalence of zinc deficiency, folate, vitamin B12 and vitamin A deficiency among

    a. Children aged 6-59 months
    b. Children aged 5-17 years
    c. Pregnant women in the first trimester

5. To assess the national micronutrient supplementation coverage including

    a. Multiple micronutrients (MMN) coverage for children 6-24 months old
    b. Vitamin A supplementation coverage for children 6-59 months old
    c. Prenatal folic acid supplementation, iron, and folate coverage among pregnant women

6. To assess the coverage of adequately iodised salt at household level

7. To assess the food security status and food consumption pattern at household level

CHAPTER 2: METHODS

2.1 Study design

It was a descriptive cross-sectional household-based study.

2.2 Study population

- Children 6 - 59 months age
- School going children aged 5 - 17 years
- Adults aged 18 - 60 years (non-lactating women and men)
- Adults > 60 years of age
- Pregnant women

The following **exclusion criteria** were applied**.**

- Institutionalised subjects
- Special diet groups
- Children with congenital disorders and chronic illnesses
- Bedridden and cognitive impaired adults

2.3 Sample size estimation

The sample size estimates were based on the prevalence of iron deficiency in children aged 6-59 months of 34% in 2012 considering the most comments micronutrient deficiency. At a confidence level of 95%, power of 90%, design effect of 1.5, and 90% response rate, minimum calculated sample size was 575 children aged 6-59 months. Considering the 80% power for provincial estimates, calculated sample size was 1200 children aged 6-59 months to estimate the provincial prevalence. The average household size was 4.3, and the proportion of the population aged 6-59 months is 8.5%. Therefore, approximately 3000 households were planned to be visited to recruit 1200 preschool children at provincial level. Using the sample size spread sheet from Nutrition Survey Toolkit hosted by WHO/MI/CDC (www.micronutrient.org/nutritiontoolkit), sample size estimates were calculated for other target groups. Table 2.1 below shows the calculated sample size of each target group for national and provincial estimates. Considering the available resources some of the biomarker analyses were limited to the national sample.

Table 2.1: Calculated sample size for national and provincial estimates*

Group	Sample size for national estimates	Sample size for provincial estimates	Final sample size
Children aged 6-59m	575	1200	1346
Children aged 5- 9 years	440	1050	667
Children aged 10-17 years	440	900	484
All women (18-60 years)**	625	1200	1560
Men (18-60 years)	410	750	792
Adults > 60 years	380	900	381
Pregnant	600	1200	1096
Total	**3470**	**7,200**	**6326**
Number of households	**1750**	**3,000**	**2936**

**Assumed that all eligible individuals are selected from each household (all children aged 6-59 months from all listed households, all school-aged children from all listed household, adult women and men from every other household, men from every other household and elderly from every other household; pregnant women were enrolled from all the listed households and remaining from antenatal clinic in the cluster; 16 per cluster(n=1200)*

2.3 Data collection tools

1. Interviewer administered questionnaire
   - Socio economic details
   - Food frequency questionnaire for 7 days
   - Food security questions
   - Coverage of nutrition interventions
   - Details about the infections
2. Anthropometric assessment
   - The height of the children (more than 2 years of age) and adults
   - The length of the children (less than 2 years of age)
   - The weight of all study participants
3. Biochemical investigations
   - Full Blood Count
   - C-Reactive Protein (CRP)
   - Serum Ferritin
   - Red Blood Cell Folate (RBC folate)
   - Serum Retinol
   - Serum Vitamin D
   - Serum Vitamin B_{12}
   - Serum Zinc

   - Urine for Urinary iodine excretion

4. Household salt iodine

2.4 Data collection

Data collection team

Health data collection was done by the staff of Department of Nutrition, MRI (n=10) and trained research assistants (n=3). Non health data questionnaire was administered by trained data collectors.

Training of survey teams

The data collection team was trained by the Principal Investigator with the assistance of the medical officers of nutrition attached to the MRI.

Data collection activity:

Planning of the data collection:

A household was considered as a group of people who share a common cooking pot. After contacting the Public Health Midwives (PHM) of the selected Grama Niladhari Divisions (GND), the staff of the Department of Nutrition, MRI trained them on selecting the households for the study.

The "starting point" was selected randomly by the PHM of the selected GND and every other household to the right was listed till the sample size was completed. The PHM visited all the selected households and informed the head of the household about the research and obtained their consent and collected their contact numbers. If the required number of pregnant women were not found in the selected households, the remaining number of pregnant mothers was selected from the pregnant mothers' registry maintained by the PHM from the selected GND and data collected at antenatal clinic.

Selection of study participants was done in the following way.

- All children aged 6-59 months from every listed household,
- school-aged children from every household,
- women from every other household,
- men from every other household and
- Adults >60 years from every other household.
- 16 pregnant women was enrolled from the clinic in each cluster

As the first step of the data collection, the enumerators of the MRI contacted the recruited households which gave their consent for the study and fixed convenient date and time for the telephone interviews. The household questionnaire and the questionnaires for the specific age groups for each household were conducted by an enumerator of the MRI.

The staff of the Department of Nutrition, MRI reviewed the completeness of the questionnaires, and the Medical Officers of Nutrition supervised them and provided feedback to the Principal Investigator.

The field data collection was conducted as the second step, after the telephone interviews were completed. The heads of the households were informed about the date, time and the venue of the field data collection and were asked to bring 50g of salt sample from home when they were coming for the anthropometric assessment. Four (04) teams from the Department of Nutrition, MRI visited the field for the data collection. Each team comprised of trained measurers, trained nursing officers and supportive staff.

Written informed consent from all the study participants and the mother/father or the immediate caregiver of the children were taken prior to the anthropometric assessment, blood, and urine collection.

The length of the children aged between 6 months to 2 years of age, height of all the study participants aged more than 2 years of age, weight of all the study participants, waist circumference of adult males and females aged between 18- 60 years of age, Mid Upper Arm Circumference (MUAC) of the pregnant women and the Calf Circumference (CC) of the adults > 60 years were measured according to the WHO recommended standard protocols. Weight was measured using Seca electronic scale (minimum 50g) and length/height was measured using stadiometers (minimum 1cm), MUAC was measured by using the MUAC tapes and the abdominal and calf circumference were measured by using non-stretchable, flat, flexible measuring tapes. The weighing instruments were calibrated before taking measurements by using standard weights.

Venous blood samples were collected by trained nursing officers attached to each team by using disposable syringes and needles. All the samples were labelled and were placed in cool boxes and were transported to the temporary field laboratory which was placed in a central site.

To obtain adequate amount of serum, at least 5 ml of venous blood was collected in two containers. First container was metal free, red top gel tube with a non-rubber stopper to separate serum for the biochemical assessments. Second container was an EDTA tube with green top to assess haemoglobin (Hb) levels and RBC folate. After collection of blood, the blood tubes were placed in a cool box and allowed to clot. All samples were processed within <2 hours of collection. Full blood count and CRP levels were assessed on the same day in the field laboratory.

At the end of each day, a drop of whole blood was used to test for C-reactive protein and remaining whole blood was centrifuged and the serum was aliquoted into at least four cryovials by pipetting, using a disposable pipette. Each aliquot of approximately 500µl was for the analysis of ferritin, zinc and vitamin D, vitamin B_{12}. Sample ID barcode was applied on each of the cryovials. The serum was stored in a freezer (-20ºC or colder) as soon as possible. Aliquoted samples of the same cluster were kept in boxes with a label of the same cluster on the box. In this way, the laboratory could easily identify which clusters were to be tested in a batch and thus minimizing the possibilities of increasing freeze/thaw cycles. A sample record/handover form was filled in indicating ID number, cluster number, and type of analysis to be done. The samples were transported to the laboratory in the Department of Nutrition, Medical Research Institute (MRI) in Colombo in dry cool boxes. Samples were received at the laboratory and were stored in a -80ºC freezer and were analysed to estimate the blood parameters.

The urine samples were collected in to wide mouthed, screw capped, sterile containers and were labelled properly by the field team. They were also transported to the field laboratory and were stored in -20ºC and were transported to the laboratory in the Department of Nutrition, Medical Research Institute (MRI) in dry cool boxes and stored in -80ºC freezer till they were analysed. Details of analytical methods are given in Table 2.2.

The salt samples collected from households were stored in dry and clean dark containers without contamination by the Public Health Inspectors of the MRI and were transported to the food laboratory of the Department of Nutrition, MRI.

The whole process of field data collection was coordinated and monitored by the medical officers of nutrition, MRI under the supervision of the Principal Investigator.

2.5 Data analysis

- All the data was manually checked and cleaned.

- WHO anthro and anthro plus software was used to analyze the anthropometry data for children and BMI was calculated for adults. WHO standard cut-off was used for categorization.

- The data was analysed by using the SPSS-20 package. Standard cutoff was used to assess the micronutrient deficiencies as provided in Table 2.3.

Table 2.2: The details of the analytical methods are given below

Test	Testing methods	Quality assurance
Haemoglobin	Haemoglobin cyanmethemoglobin method – Erba elite 3-part haematology analyser	Samples giving high/ low values was measured in duplicates. Internal control samples were run with each batch of samples
Ferritin	DiaSorin LIAISON XL analyser	
Zinc	ICP-MS	
C-reactive protein	Latex agglutination method	Quality control samples was analysed with each batch of samples
Vitamin A	High-performance Liquid Chromatography (HPLC)	Internal Quality Control samples of 2 levels was run with each batch of Samples.
Vitamin D	DiaSorin LIAISON XL analyser	
Vitamin B_{12}	DiaSorin LIAISON XL analyser	
Folate	CDC developed microbiologic assay	
Urine iodine	Ammonium persulfate method	CDC EQUIP programme
Salt iodine	Titration method	Internal Quality Control samples of 2 levels was run with each batch of Samples.

Table 2.3: Recommended cut-off values for each laboratory test

Indicators/ laboratory tests	Recommended cut-off values and definitions of a public health problem, where applicable
Anaemia/ Haemoglobin [a,b]	Children 6-59 mo: < 11.0 g/dL Children 5-11 y: <11.5 g/dL Children 12-14 y: <12.0 g/dL Non-pregnant women 15-49 y: <12.0 g/dL Pregnant women 15-49 y: <11.0 g/dL Men ≥15 y: <13.0 g/dL Hemoglobin values are adjusted for altitude as below. Altitude in Meters Adjustment factor (g/dL) <1000 - No adjustment ≥1000 <1500 - +0.2 Public health problem - Anaemia prevalence: ≤4.9% - normal 5.0 - 19.9 % - mild 20.0 - 39.9 % - moderate ≥40 % - severe
Iron Deficiency / Ferritin [b]	Children <5 y: <12 µg /L Children <5 y with inflammation: <30 ug/L Children ≥5y and adults: <15 µg/L Children ≥5y and adults with inflammation: <70 µg/L
Vitamin D Deficiency	Children < 5 years: < 20 µg/L Children ≥5y and adults: < 20 µg/L
Vitamin A deficiency/ Serum retinol [c]	For all age groups: Mild <0.70 µmol/L Moderate 0.35 - 0.69 µmol/L Severe < 0.35 µmol/L Definition of a public health problem: prevalence of vitamin A deficiency (based on low serum retinol and unadjusted) 2-9% - mild 10-19% - moderate ≥20% - severe

Indicators/ laboratory tests	Recommended cut-off values and definitions of a public health problem, where applicable
Iodine/ Urinary iodine[d]	Children (1-14 y) and Non-Pregnant Women (15-49 y): Population median: Excess ≥300 µg/L Above requirements 200-299 µg/L Sufficient 100-199 µg/L Mild deficiency 50-99 µg/L Moderate deficiency 20-49 µg/L Severe deficiency<20 µg/L Pregnant Women (15-49 y): Excess ≥500 µg/L Insufficient <150 µg/L
Folic acid/ RBC folate[e]	Children 6-59 mo: <100 ng/mL (<226.5 nmol/L) Adolescent and adult women (10-60 y): <151 ng/mL (340 nmol/L)
Vitamin B_{12} / Serum B_{12}[f]	For all age groups: <160 pg/mL
Zinc/ Serum zinc[g,h]	Children 6-59 mo.: Morning, non-fasting: <65µg/dL Afternoon, non-fasting: <57 µg/dL Non-pregnant women 18-60 y: Morning, non-fasting: <66µg/dL Afternoon, non-fasting: <59 µg/dL Morning is defined as a sample collected before 1200 hours and afternoon as after 1200 hours. To convert to µmol/L divide by 6.54 Zinc deficiency is of public health concern when the prevalence of low serum zinc concentration is greater than 20%.

[a] WHO. Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity. Vitamin and Mineral Nutrition Information System. Geneva, World Health Organization, 2011 (WHO/NMH/NHD/MNM/11.1) (http://www.who.int/vmnis/indicators/haemoglobin.pdf, Assessed January 28, 2013).

[b] UNICEF, United Nations University, WHO. Iron deficiency anemia, assessment, prevention, and control: a guide for programme managers. WHO/NUT/96.10. 2001. Geneva, WHO.

[c] WHO. Indicators for assessing vitamin A deficiency and their application in monitoring and evaluating intervention programmes. 1996. Geneva, WHO.

[d] WHO. Assessment of iodine deficiency disorders and monitoring their elimination. Accessed at: http://whqlibdoc.who.int/publications/2007/9789241595827_eng.pdf

[e] Cut-offs for RBC folate among adults are based on homocysteine values or incidence of neural tube defects, which are not priority health events for children 6-59 months so cuts off for children based on macrocytic anemia are suggested.

[f] WHO Technical Consultation. Conclusions of a WHO Technical Consultation on folate and vitamin B_{12} deficiencies. Food and Nutrition Bulletin 2008; 29(2 (Supplement)):S238-S244.

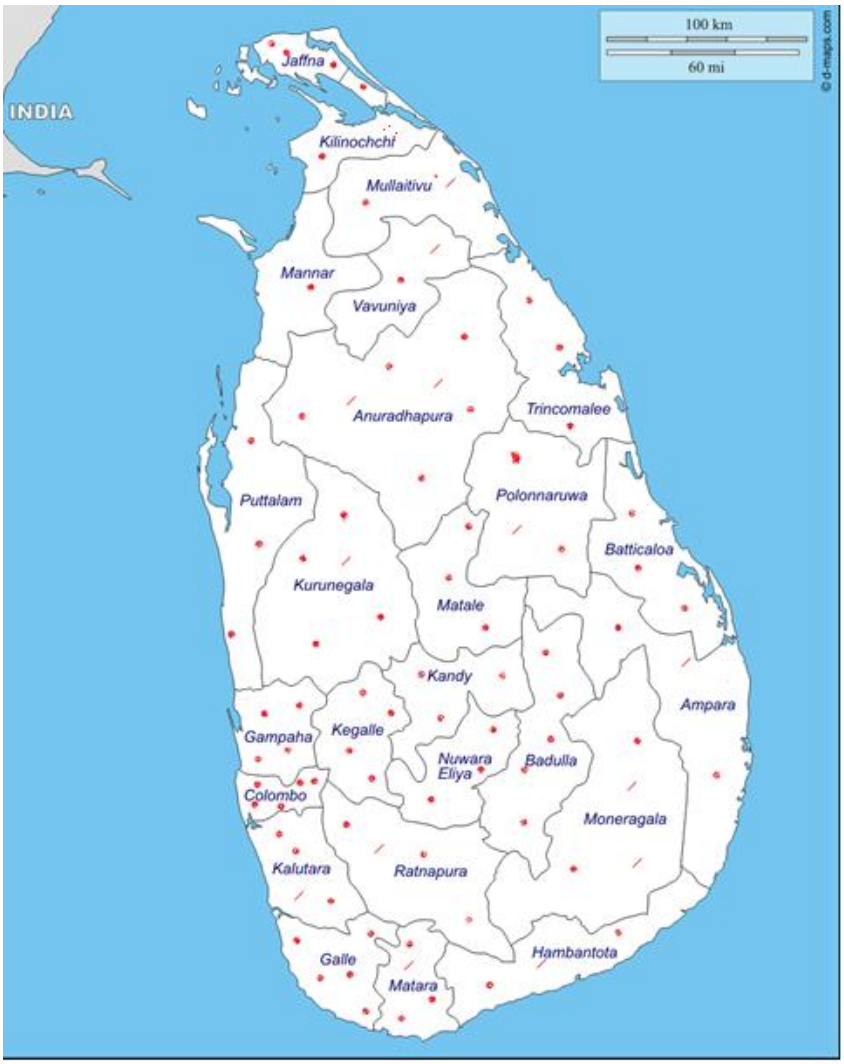
[g] IZiNCG Technical Brief. No. 2, 2007. Assessing population zinc status with serum zinc concentration. Accessed at: http://www.izincg.org/pdf/English_brief2.pdf.

[h] deBenoist B, Darnton-Hill I, Davidsson L, Fonataine O, Hotz C. Conclusions of the Joint WHO/UNICEF/IAEA/IZiNCG interagency meeting on zinc status indicators. Food and Nutrition Bulletin 2007;28(3):S480-S485.

CHAPTER 3: HOUSEHOLD CHARACTERISTICS

A total of 2,936 households were covered from 105 GND, which is 97.9% participation rate. Figure 3.1 presents the sample distribution in the country. Each dot represents a cluster.

Figure 3.1: Map of Sri Lanka indicating clusters



Flow chart of the study population included in biochemical assessments and anthropometry measurements were presented in Figure 3.2.

Figure 3.2: Flow chart of the study population

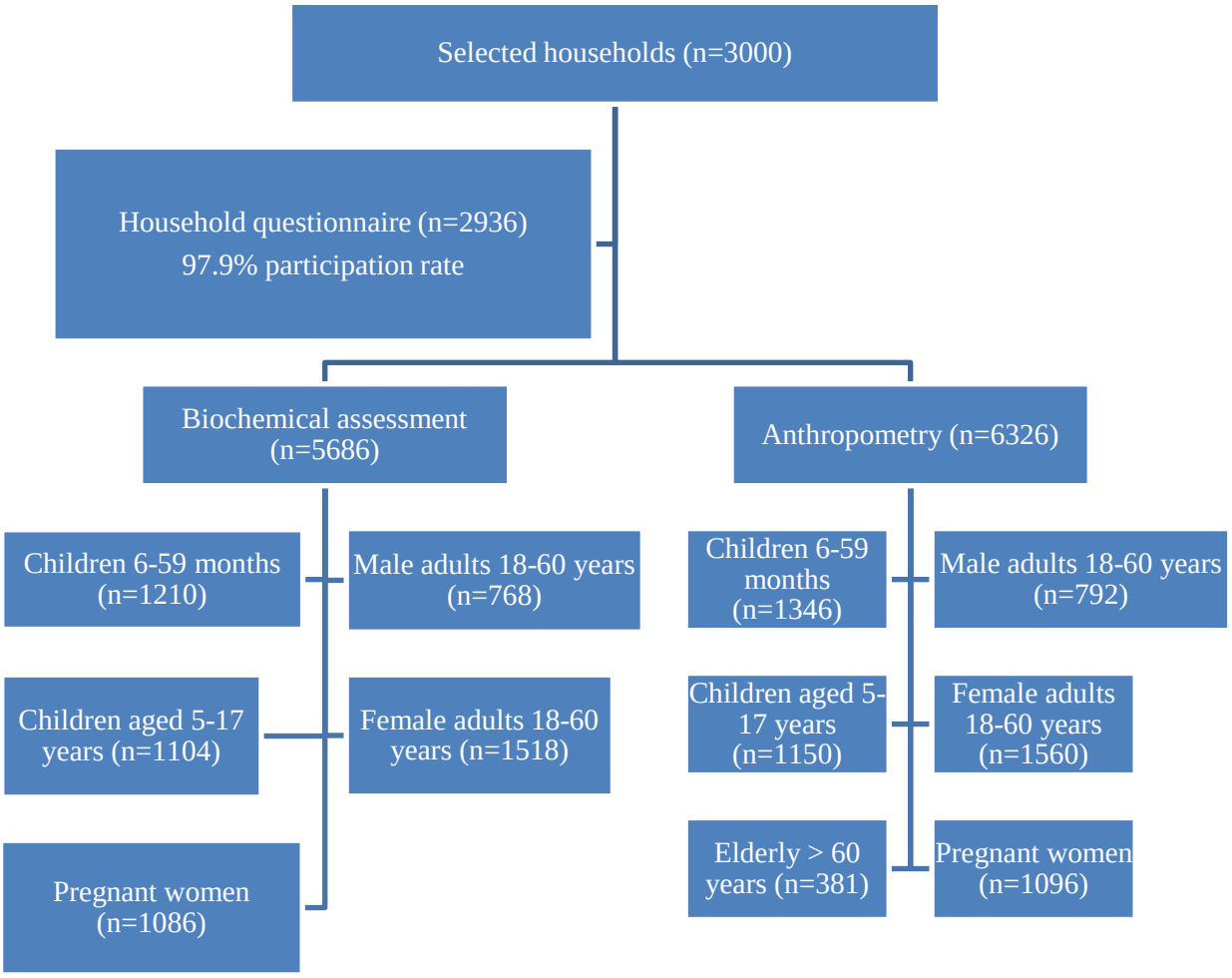
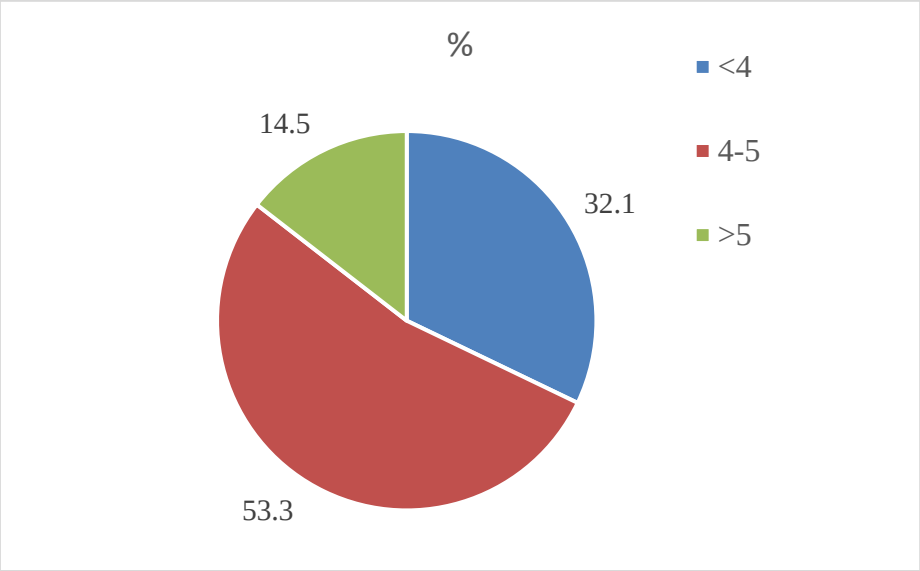


Figure 3.3 shows the number of household members in the households and mean household members was 4.2 ± 1.4.

Figure 3.3: Number of household members



3.1 Socio-demographic and socio-economic profile of HHs

3.1.1 Household income status

Table 3.1 shows the sector distribution of the sample and median household income was Rs. 40,000 (25^{th} -75^{th} percentile 25,000-75,000).

Table 3.1: Socio demographic and socio-economic characteristics of HH

Socio demographic and economic characteristics	No. (%)
Sector	
Urban	384 (13.1)
Rural	2310 (78.7)
Estate	242 (8.2)
Mean (SD) number of household members	4.2 (1.4)
Median HH income (25^{th} -75^{th} percentile) in Rupees	40,000 (25,000-75,000)
N	**2,936**

3.1.2 Ethnicity and religion

Table 3.2 shows the ethnicity and religion of the head of the HH. Majority belonged to Sinhalese ethnicity and Buddhist religion.

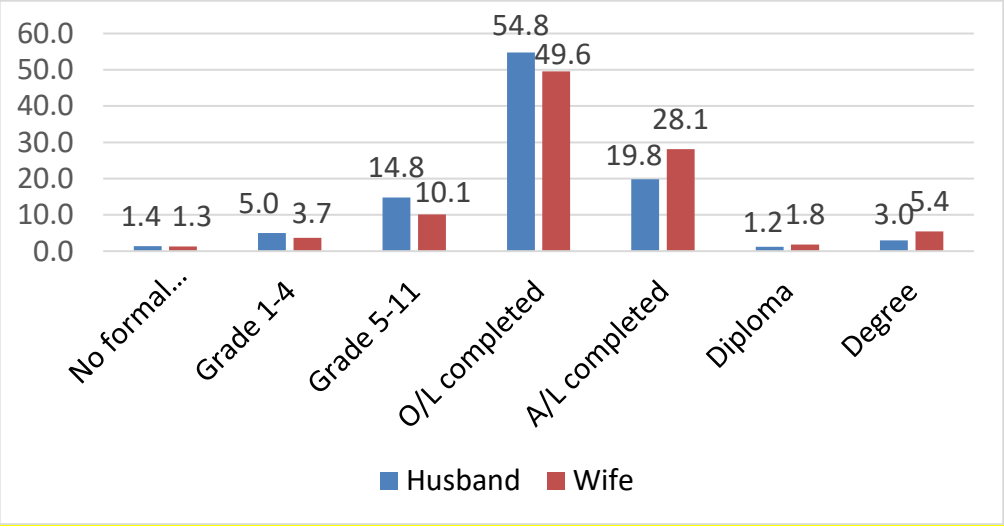
Table 3.2: Ethnicity and religion of head of the HH

Ethnicity and religion	%
Ethnicity	
Sinhala	74.6
Tamil	18.0
Muslim	6.4
Other (Malay, Burgher)	1.0
Religion	
Buddhist	71.9
Christian/Catholics	5.8
Hindu	15.1
Islam	7.0
Other	0.2
N	**2,936**

3.1.3 Educational status

As shown in Figure 3.4, among the male heads of the HHs surveyed, 54.8% had completed GCE O/L and 19.8% had completed A/L.

Figure 3.4: Educational status of husband and wife



A further 14.8% had completed secondary education (grade 5-11), and 5.0% had completed primary education (grade 1-4), while only about 3.0% had received higher education. About half (49.6%) of wife of head of HHs surveyed/female head of HHs had completed GCE O/L, 10.1% had completed secondary education, 28.1% had completed GCE A/L, 3.7% had completed primary education and 5.4% had received higher education. In men and women 1.4%

and 1.3% respectively had not received any formal education at all. A higher proportion of women had completed their GCE A/L and received higher education when compared to males.

3.1.4. Productive and non-productive assets

Table 3.3 shows the productive and non-productive assets available at household level. Most households (98.7%) owned a mobile phone, which was the most commonly available asset. Around 95% of the surveyed HH also owned jewellery, 86.9% of HH had a TV, 58.1% had radio and 68.9% owned a refrigerator. Motorcycles were the most owned transport at 52.6%.

Table 3.3: Availability of productive and non-productive assets

Availability of assets (n=2924)	%
Mobile phone	98.7
Land phone	8.6
Clock	94.9
TV	86.9
Radio	58.1
Refrigerator	68.9
Washing machine	27.8
Sewing machine	33.6
Bicycle	24.3
Motorcycle	52.6
Three-wheeler	18.2
Car/bus/lorry	10.4
Tractor/land master/ combine harvester	1.8
Motorboat	0.2
Computer	19.4
Internet facility	46.8
Jewelry	95.4

3.1.5 Physical facilities, water, and sanitation

Table 3.4 shows that half of the houses surveyed were built using cement block walls, with a further 42.2% built from brick or kaboks. Only a minority of houses (2.5%) had walls built of other materials. 76.9% of houses had cemented floors and 47% had an asbestos roof. The vast majority (97.9%) of HHs had electricity.

Table 3.4: Availability of Physical facilities

Availability of physical facilities	%

Type of wall	
Brick / Kabook	42.2
Cement block	55.3
Other	2.5
Type of floor	
Cement	76.9
Tile/Terrazzo	17.9
Other	6.2
Type of roof	
Asbestos	47.0
Tile	33.2
Corrugated sheet/Tin	13.3
Concrete	5.5
Other	1.0
Electricity available	97.9
Solar power available	1.2

As shown in Table 3.5, many different types of water sources were used by HHs. However, 51% of HH had treated water prior to drinking. Boiling was the most popular method (83%) followed by filtering (23.9%). About 98.5% of the HHs had a sanitary latrine.

Table 3.5: Availability of water and sanitation

Availability of facilities	%
Type of water facilities	

Piped water (water board)	39.7
Piped water (community)	5.2
Piped water (protected well)	13.7
Piped water (unprotected well)	3.7
Public tab	0.9
Protected well	10.3
RO water	7.6
Tube well	3.7
Unprotected well	1.3
Protected spring	7.0
Unprotected spring	1.1
Bottled water	4.1
Other	1.6
Treating water prior to drink	**51.0**
Method of treatment	
Boiling	83.0
Water filter	2.6
Special filter	21.3
Strain with cloth	5.7
Bleach	0.7
Other	0.7
Type of Toilet	
Flush	98.5
Temporary	0.4
No	1.0
Sharing of toilet	**5.0**

CHAPTER 4: CHILDREN AGED 6-59 MONTHS

A total of 1510 children aged 6-59 months were listed in the selected households and the questionnaire was administered for all of them. However, only 1346 participated in anthropometry assessment and 1210 were included in the biochemical assessment to fulfil the calculated sample size.

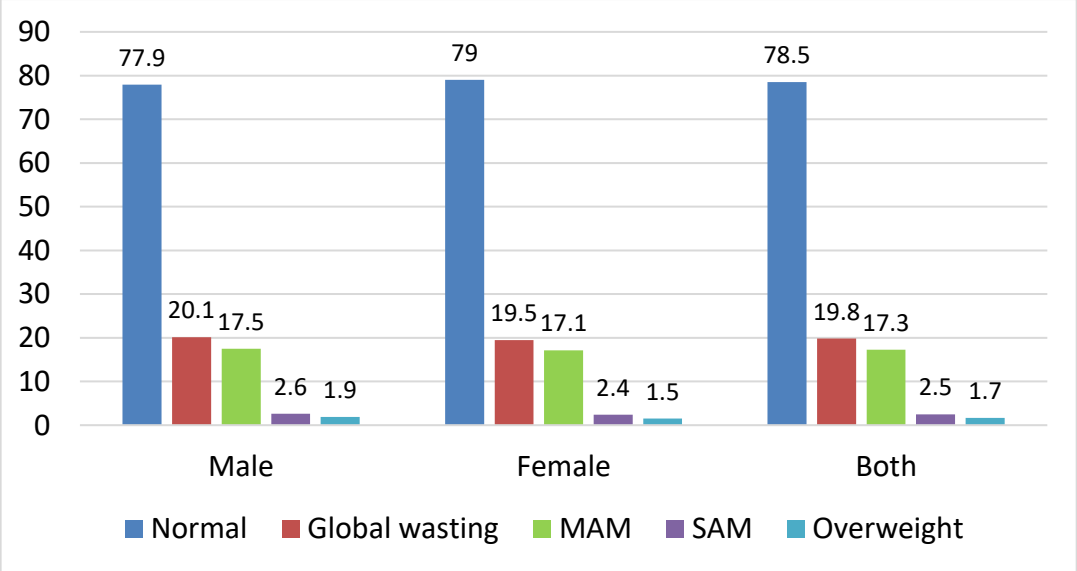
4.1 Nutrition status

Table 4.1 shows the age and sex distribution of the children aged 6-59 months who were included for anthropometry (weight and height/length). In the overall sample, boys: girls' ratio is 1.0.

Table 4.1: Age and sex distribution of children aged 6-59 months

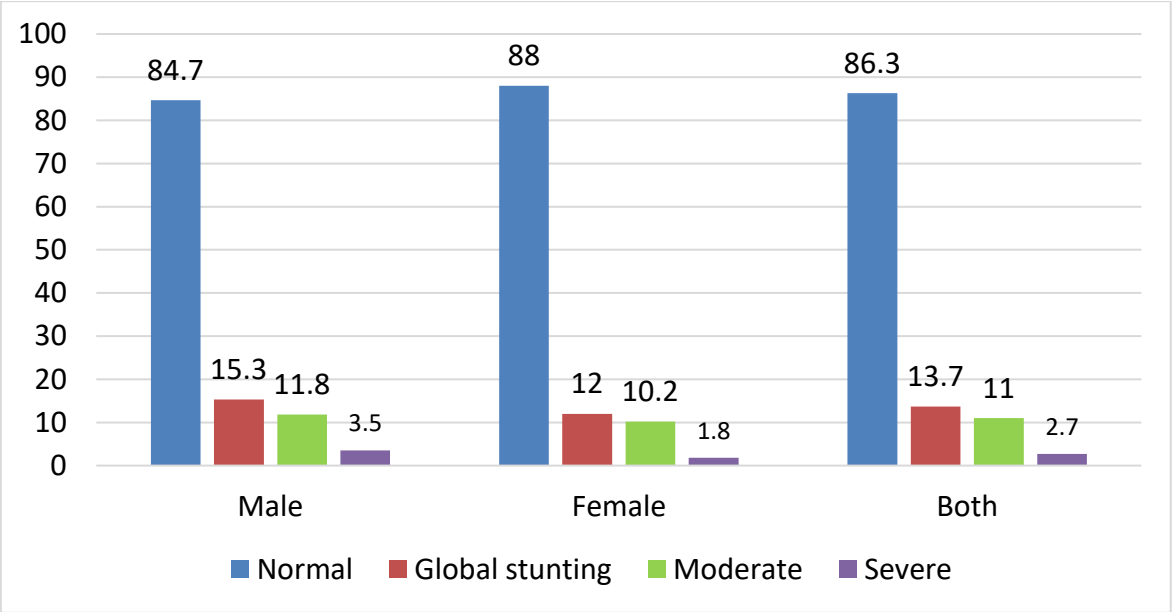
Age	Boys		Girls		Total		Ratio
(months)	no.	%	no.	%	no.	%	Boy: girl
6-11	70	10.3	77	11.6	147	10.9	0.9
12-23	136	20.0	126	18.9	262	19.5	1.1
24-35	169	24.9	138	20.7	307	22.8	1.2
36-47	162	21.0	153	25.8	315	23.4	1.1
48-59	143	21.0	172	25.8	315	23.4	0.8
Total	**680**	**50.5**	**666**	**49.5**	**1346**	**100.0**	**1.0**

Figure 4.1: Prevalence of wasting and overweight in children 6-59 months of age



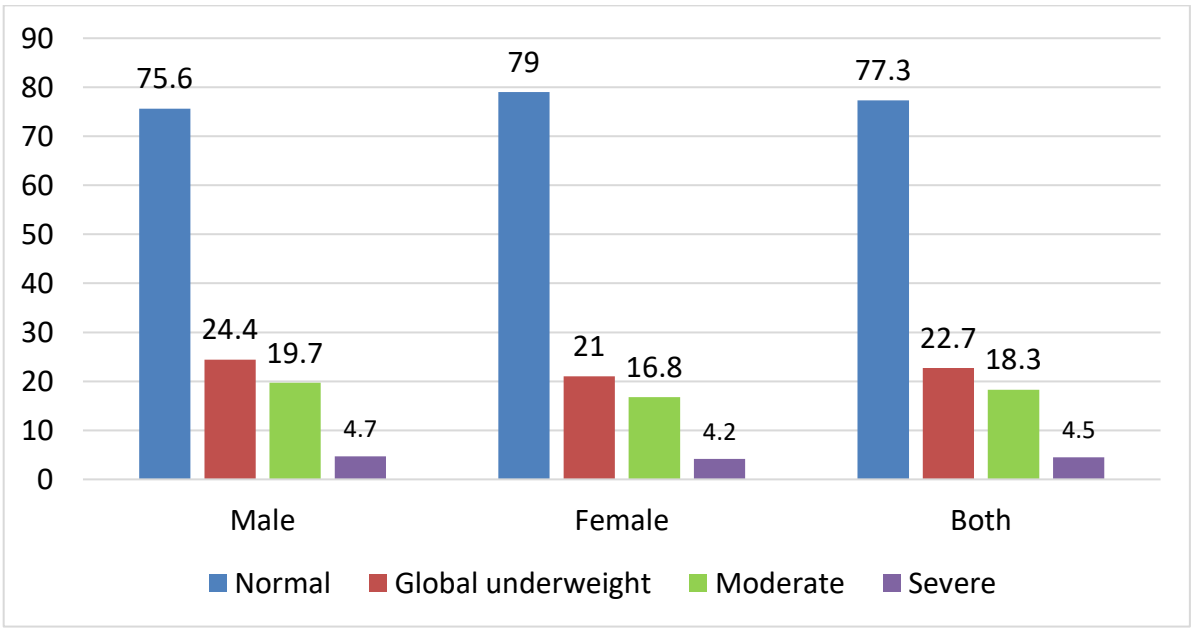
As shown in Figure 4.1, the prevalence of global wasting, severe acute malnutrition (SAM), moderate acute malnutrition (MAM), and overweight among children aged 6-59 months was 19.8%, 2.5%, 17.3% and 1.7% percent respectively. Overall prevalence of wasting is higher than the national prevalence in 2016 (15.1%). The prevalence of global wasting, severe acute malnutrition, moderate acute malnutrition, overweight and obesity are more in boys.

Figure 4.2: Prevalence of stunting in children 6-59 months of age



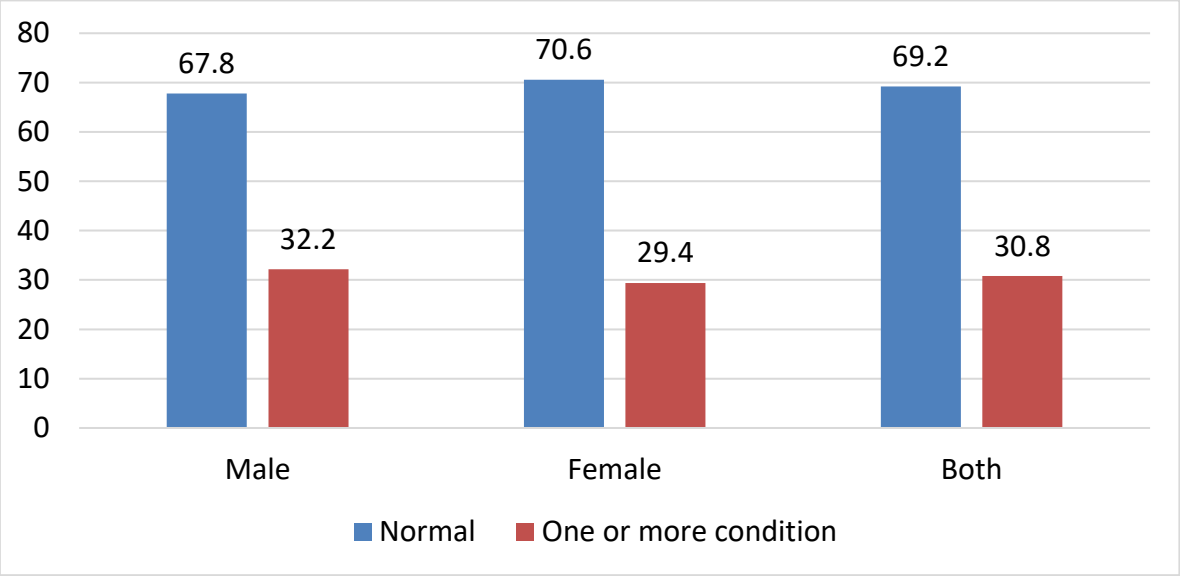
The prevalence of global, severe and moderate stunting among children aged 6-59 months was 13.7%, 2.7% and 11.0% respectively (Figure 4.2). Global, moderate and severe stunting is higher in boys than girls. Overall stunting rate is lower than 2016 national prevalence (17.3%).

Figure 4.3: Prevalence of underweight in children 6-59 months of age



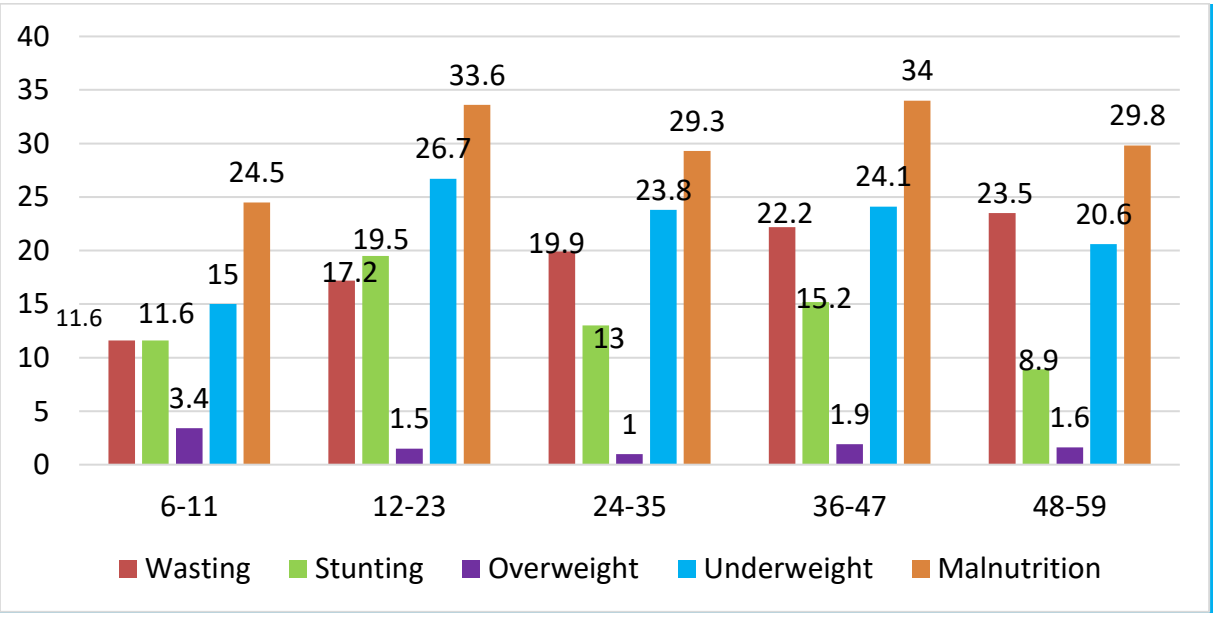
The prevalence of global, severe and moderate underweight among children aged 6-59 months was 22.7%, 4.5% and 18.3% respectively (Figure 4.3). While global, moderate and severe underweight are more in boys compared to girls. Overall prevalence of underweight is higher than the 2016 national prevalence (21.1%).

Figure 4.4: Prevalence of malnutrition (wasting, stunting, underweight, overweight, or more than one condition) in children 6-59 months of age



When one or more indicators of poor nutritional status (either wasting or stunting or underweight or overweight or more than one condition) is defined as "**malnutrition**". Malnutrition is higher among boys than girls. Figure 4.4 shows that about one third (30.8%) of children aged 6-59 months in the study sample is malnourished.

Figure 4.5: Wasting, stunting, underweight, overweight, and overall malnutrition by age



The prevalence of children with malnutrition is highest in the 36-47 months age category. Wasting is highest in 48-59 years age group, while overweight is highest among 6-11 months age group (Figure 4.5). There is an increasing trend of wasting with increasing age, from 11.6% to 23.5%. The lowest wasting, and malnutrition was observed among children aged 6-11 months.

Inter provincial comparisons show the prevalence of wasting to range between a low value of 12.1% in Sabaragamuwa province to 27.1% in Northwestern province (Table 4.2). Among the 9 provinces that have wasting prevalence below the average for national level were Central, Uva and Sabaragamuwa provinces. The other provinces reported prevalence of wasting figures higher than that for national level.

The prevalence of stunting ranged between 8.3% in Northern province to 21.5% in Central province (Table 4.2). Among the 9 provinces that have stunting prevalence higher the average for national level were Central, Southern, Northwestern, Northcentral, Uva and Sabaragamuwa provinces. The other provinces reported stunting figures lower than that for national level. The highest prevalence of stunting was observed in the estate sector (33.1%).

Table 4.2: Prevalence (%) of wasting, stunting, underweight and overweight of children 6-59 months by province

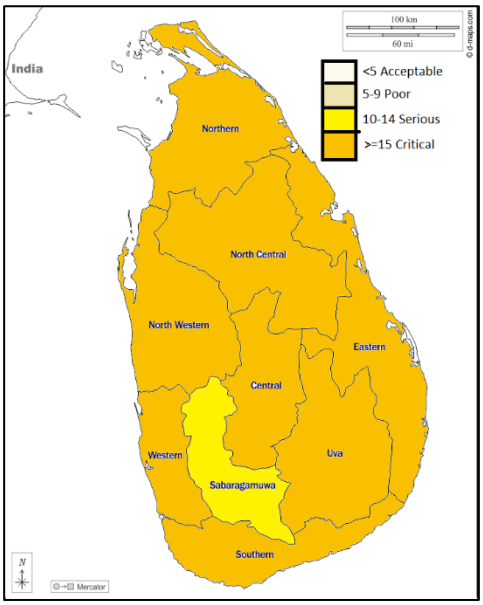
Province	Wasting	Stunting	Underweight	Overweight	Malnutrition	n
Western	20.3	8.5	18.9	3.3	29.2	212
Central	15.9	21.5	22.1	1.0	33.8	195
Southern	20.2	13.9	22.1	2.4	31.2	208
Northern	22.6	8.3	20.8	1.8	29.8	168
Eastern	22.5	6.2	20.0	0.0	26.2	80
Northwestern	27.1	18.6	38.0	0.0	38.0	129
Northcentral	20.0	14.3	23.8	2.9	30.5	105
Uva	19.2	15.2	23.2	0.0	31.2	125
Sabaragamuwa	12.1	14.5	18.5	2.4	25.0	124
Sector						
Urban	22.0	9.1	19.5	4.3	31.1	164
Rural	20.2	11.8	22.2	1.5	29.5	1043
Estate	14.4	33.1	30.2	0.0	40.3	139
Sri Lanka	**19.8**	**13.7**	**22.7**	**1.7**	**30.8**	**1346**

The prevalence of underweight ranged between 18.5% in Sabaragamuwa province to 38.0% in Northwestern province (Table 4.2). Among the 9 provinces that have underweight prevalence lower than the average for national level were Western, Central, Southern, Northern, Eastern and Sabaragamuwa provinces. The other provinces reported prevalence of underweight figures higher than that for national level.

The prevalence of overweight was highest in Western province (3.3%) (Table 4.2). Among the 9 provinces that have overweight prevalence lower than the average for national level were Central, Eastern, Northwestern and Uva provinces. The other provinces reported prevalence of overweight figures higher than that for national level.

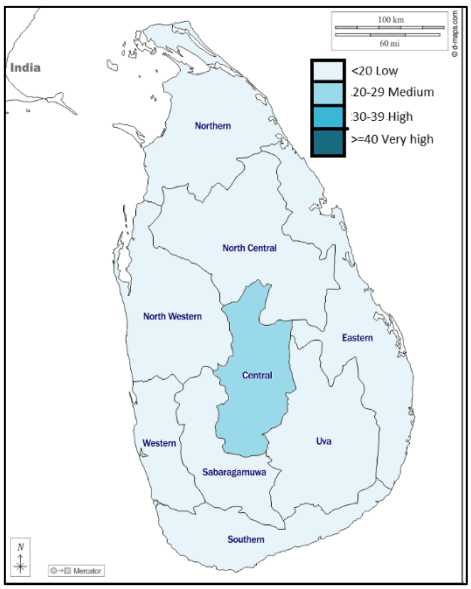
The highest prevalence of stunting, underweight and malnutrition was observed in the estate sector. The highest prevalence of wasting was found in the urban sector.

Figure 4.6: Provincial map of Sri Lanka according to severity of wasting



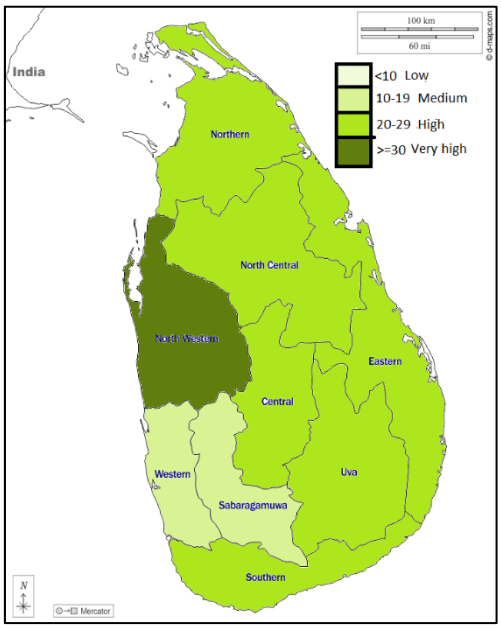
According to the cut-off values in the prevalence of wasting that identified this problem as of public health significance (specified by the WHO), wasting is a critical public health problem in all provinces except in Sabaragamuwa province, indicating the need for implementing effective interventions urgently (Figure 4.6).

Figure 4.7: Provincial map of Sri Lanka according to severity of stunting



According to the cut-off values specified by WHO, for prevalence of stunting as being of public health significance, stunting is a low public health problem in all provinces except in Central province (Figure 4.7).

Figure 4.8: Provincial map of Sri Lanka according to severity of underweight

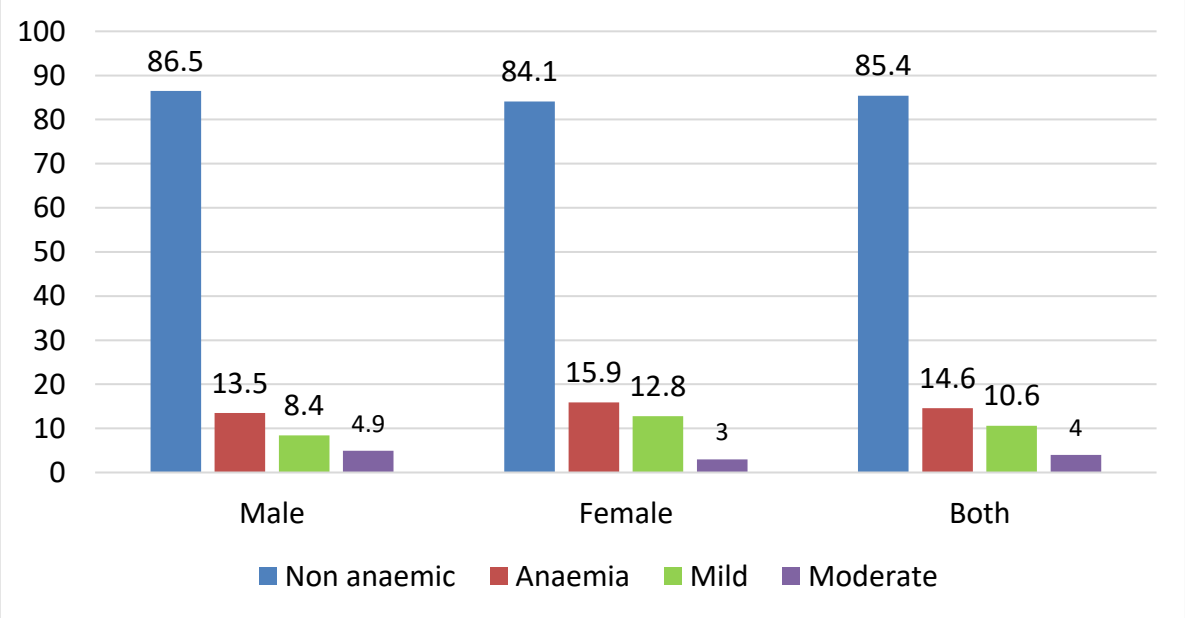


According to the prevalence figures that identify underweight as a problem of public health significance as specified by the WHO, underweight is a public health problem of very high priority in the Northwestern province. Western and Sabaragamuwa provinces showed the level of public health significance to be of a 'medium' degree. All the other provinces indicate being underweight as a high public health problem (Figure 4.8).

4.2 Anaemia

The haemoglobin (Hb) levels of 1210 children in the age group 6–59 months were assessed using the Erba elite 3-part hematology analyzer with venous blood. Response rate was 89.9%. Mean Hb was 12.0±1.1 g/dL. The cutoff point - Hb <11.0 gms/dL and adjusted for altitudes was used to define anaemia. Mild, moderate, and severe anaemia was defined as Hb 10.0-10.9 g/dL, 7.0-9.9 g/dL and <7g/dL respectively.

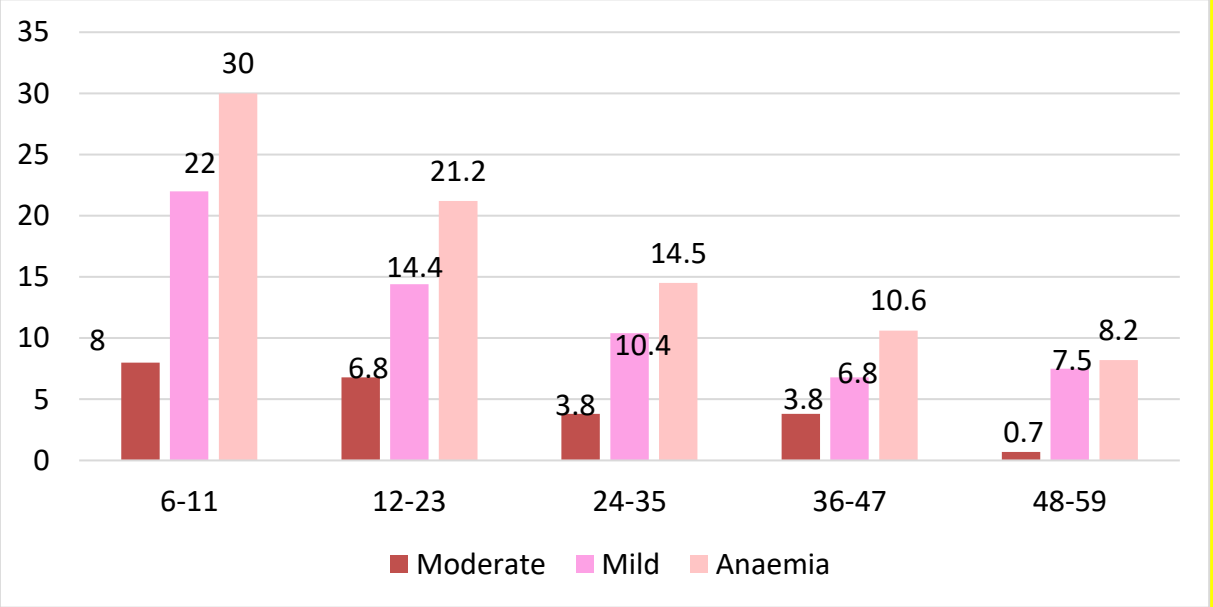
Figure 4.9: Prevalence of anaemia in children 6-59 months of age



The prevalence of overall, mild and moderate anaemia among children aged 6-59 months was 14.6%, 10.6% and 4.0% respectively (Figure 4.9). Only one male child was found with severe anaemia and the prevalence was 0.1%. While overall and mild anaemia was more in girls

compared to boys. Overall prevalence of anaemia is lower than the 2012 national prevalence (15.1%).

Figure 4.10: Prevalence of anaemia by age



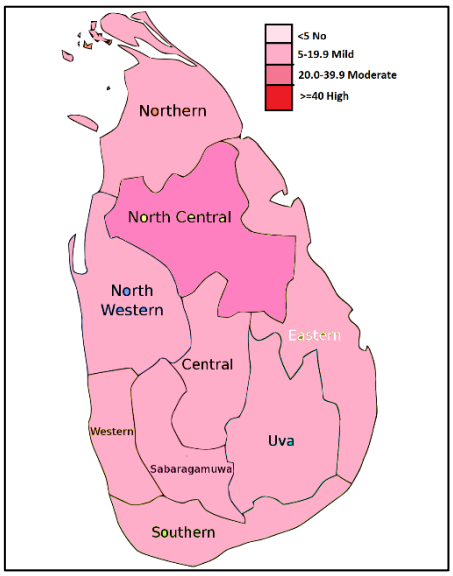
The prevalence of children with overall anaemia, moderate and mild anaemia was higher in the 6-11 months age category. There is a decreasing trend of anaemia with increasing age from 30.0% to 8.2% (Figure 4.10).

Table 4.3: Prevalence of anaemia by province

Province	Moderate anaemia	Mild anaemia	Overall anaemia	Non anaemic	N
Western	4.3	9.1	13.4	86.6	187
Central	2.8	7.8	11.2	88.8	179
Southern	2.2	12.0	14.2	85.8	183
Northern	3.7	11.8	15.4	84.6	136
Eastern	5.6	2.8	8.3	91.7	72
Northwestern	6.6	11.5	18.0	82.0	122
Northcentral	6.2	14.4	20.6	79.4	97
Uva	2.6	14.7	17.2	82.8	116
Sabaragamuwa	4.2	10.2	14.4	85.6	118
Sector					
Urban	5.7	12.1	17.9	82.1	140
Rural	4.0	10.6	14.7	85.3	934
Estate	2.2	8.8	11.0	89.0	136
Sri Lanka	**4.0**	**10.6**	**14.6**	**85.4**	**1210**

Inter provincial comparisons show the prevalence to range between a low value of 8.3% in Eastern province to 20.6% in Northcentral province (Table 4.3). Among 9 provinces that have prevalence below the average for national level were Western, Central, Southern, Eastern and Sabaragamuwa provinces. The other provinces reported prevalence figures higher than that for national level.

Figure 4.11: Provincial map of Sri Lanka according to severity of anaemia

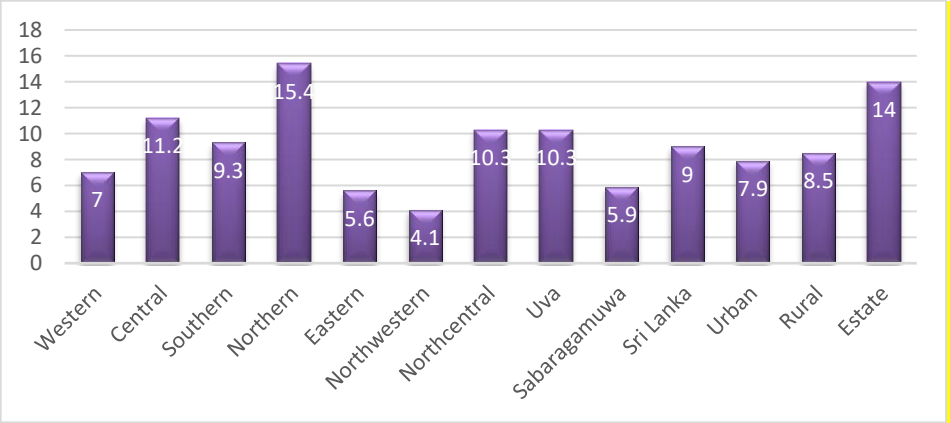


According to the prevalence values that identify anaemia as a problem of public health significance as specified by the WHO, the findings of this study shows that anaemia is of public health significance at a 'mild' level, in all provinces except in Northcentral province. (Figure 4.11 and Table 4.3).

4.3 Acute inflammation

Acute Reactive Phase (CRP) levels were determined to identify acute infections. When the CRP level was higher than 5 mg/L, it was defined as a presence of acute inflammation. In the study sample, 9.0% of children 6-59 months had acute inflammation and varied from 4.1% in Northwestern province to 15.4% in Northern province (Figure 4.11). Highest acute inflammation was found in children living estate sector (14%).

Figure 4.11: Prevalence of acute inflammation in different provinces and sectors



4.4 Iron deficiency

Serum ferritin values of 1175 children in the age group 6–59 months were assessed using the DiaSorine LIAISON XL analyser with serum. Mean ferritin level was 39.1±28.7 µg/L. The cutoff point of ferritin <12.0 µg/L when CRP is<6 mg/L and ferritin <15.0 µg/L when CRP is >5 mg/L was used to define iron deficiency (ID).

The prevalence of ID among children aged 6-59 months was 5.4% (Figure 4.12). There is no significant difference between boys and girls. The prevalence of ID is lower than the 2012 national prevalence (33.6%).

Figure 4.12: Prevalence of iron deficiency in children 6-59 months of age by sex

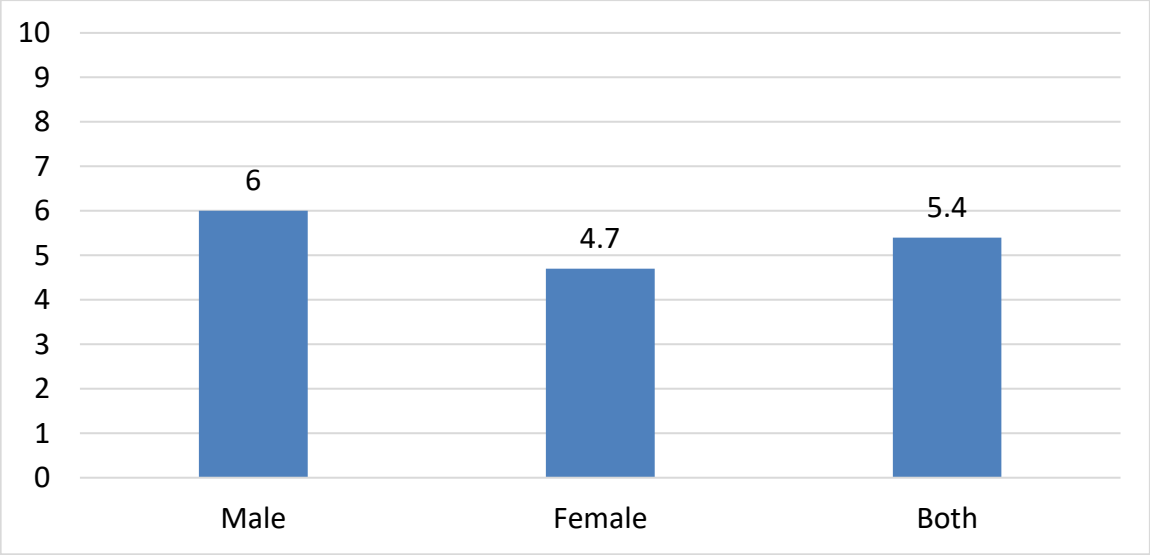
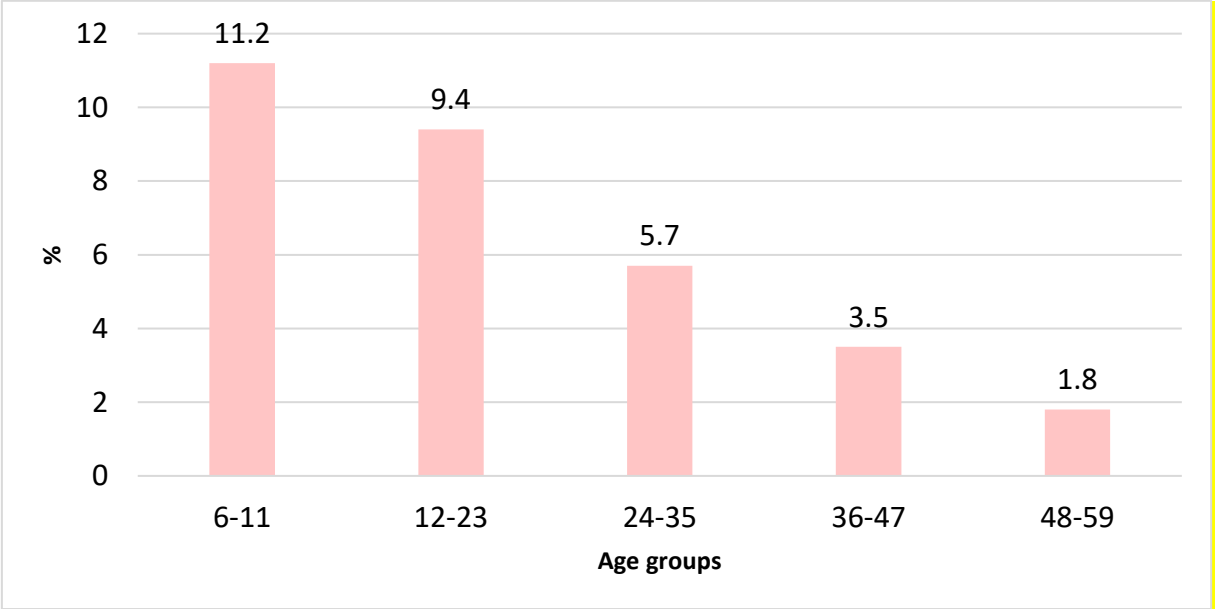


Figure 4.13: Prevalence (%) of iron deficiency by age



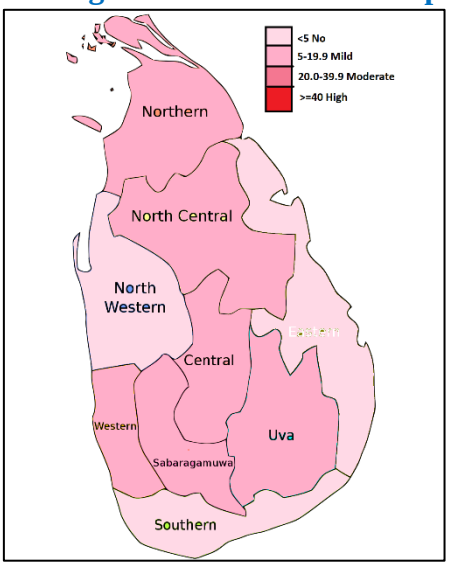
The prevalence of children with ID was higher in the 6-11 months age category. There is a decreasing trend of ID with increasing age from 11.2% to 1.8% (Figure 4.13).

Inter provincial comparisons show the prevalence to range between a low value of 2.9% in Eastern province to 8.6% in Central province (Table 4.4). Among 9 provinces that have prevalence higher the average for national level were Central and Sabaragamuwa provinces. The other provinces reported prevalence figures lower than national level. The highest prevalence of iron deficiency was found in the estate sector (12.1%).

Table 4.4: Prevalence (%) of iron deficiency by province

Province	ID	N
Western	5.0	181
Central	8.6	174
Southern	4.0	177
Northern	5.3	131
Eastern	2.9	70
Northwestern	4.2	119
Northcentral	5.4	93
Uva	5.3	114
Sabaragamuwa	6.0	116
Sector		
Urban	5.0	139
Rural	4.4	904
Estate	12.1	132
Sri Lanka	**5.4**	**1175**

Figure 4.14: Provincial map of Sri Lanka according to severity of iron deficiency



According to the prevalence values that identify ID as a problem of public health significance as specified by the WHO, the findings of this study shows that ID is of public health significance at a 'mild' level, in 6 out of 9 provinces and in overall Sri Lanka. However, ID is not a public health issue in Southern, Eastern and Northwestern provinces (Figure 4.14 and Table 4.4).

4.5 Iron deficiency anaemia

Iron deficiency anaemia (IDA) was defined as presence of both anaemia and iron deficiency. The highest prevalence of IDA was seen among the 6-11 months old children, with a trend of decreasing prevalence with increasing age. Boys showed a higher prevalence compared to the girls.

Inter provincial comparisons show the range of prevalence between 0.0% in Eastern and Uva provinces to 4.3% in Sabaragamuwa province in this sample (Table 4.5). All the provinces had IDA below 5%.

Table 4.5: Prevalence of iron deficiency anaemia (IDA) among children aged 6-59 months by sex, age, and provinces.

Background characteristic	No	% of Children with IDA
Age of the child in months		
6-11	98	4.1
12-23	223	3.6
24-35	281	1.8
36-47	288	1.0
48-59	285	0.4
Sex of the child		
Male	600	2.0
Female	575	1.6
Province		
Western	181	2.2
Central	174	1.7
Southern	177	0.6
Northern	131	3.1
Eastern	70	0.0
Northwestern	119	1.7
Northcentral	93	2.2
Uva	114	0.0
Sabaragamuwa	116	4.3
Sector		
Urban	139	3.6
Rural	904	1.2
Estate	132	2.3
Sri Lanka	**1175**	**1.8**

4.6 Vitamin D deficiency

Serum vitamin D levels of 749 children in the age group 6–59 months were assessed using the DiaSorine LIAISON XL analyser with serum. Mean vitamin D level was 24.6±7.2 ng/mL. The cutoff point of vitamin D <20.0 ng/mL was used to define vitamin D deficiency (VDD).

The prevalence of VDD among children aged 6-59 months was 26.2% (Figure 4.15). There is no significant difference between boys and girls.

Figure 4.15: Prevalence of vitamin D deficiency in children 6-59 months of age by sex

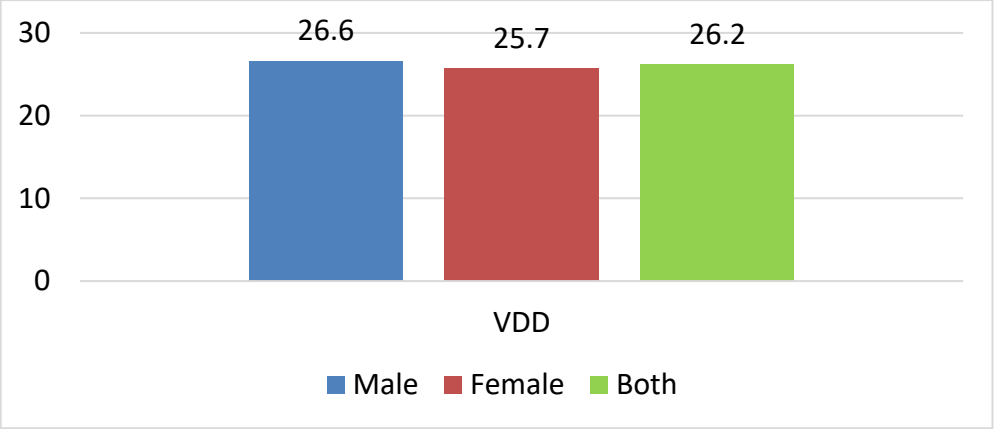
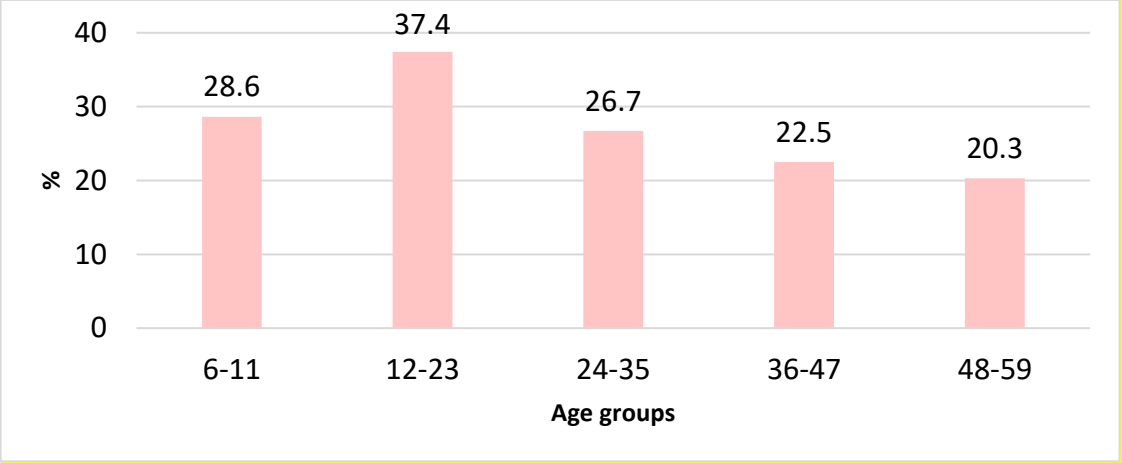


Figure 4.16: Prevalence (%) of vitamin D deficiency by age



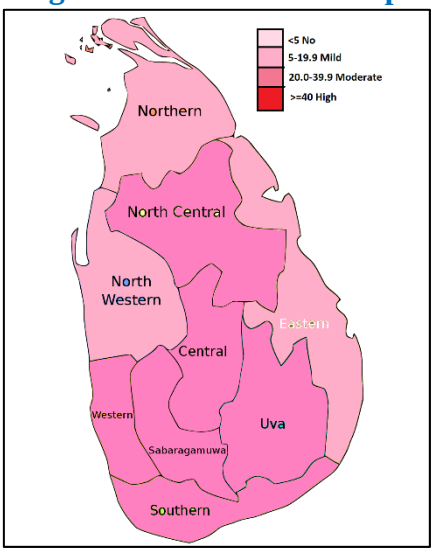
The prevalence of children with VDD was higher in the 12-23 months age category. There is a decreasing trend of VDD with increasing age from 12-23 years age group from 37.4% to 20.3% (Figure 4.16).

Inter provincial comparisons show the prevalence to range between a low value of 9.1% in Northern province to 38.8% in Central province (Table 4.6). Among 9 provinces that have prevalence above the average for national level were Central, Southern, Northcentral and Western and Sabaragamuwa provinces. The other provinces reported prevalence figures lower than that for national level.

Table 4.6: Prevalence (%) of VDD by province

Province	VDD	N
Western	26.3	137
Central	38.8	98
Southern	32.4	105
Northern	9.1	88
Eastern	15.9	44
Northwestern	18.3	71
Northcentral	28.1	64
Uva	25.7	70
Sabaragamuwa	33.3	72
Sector		
Urban	25.2	103
Rural	25.1	578
Estate	36.8	68
Sri Lanka	**26.2**	**749**

Figure 4.17: Provincial map of Sri Lanka according to severity of vitamin D deficiency

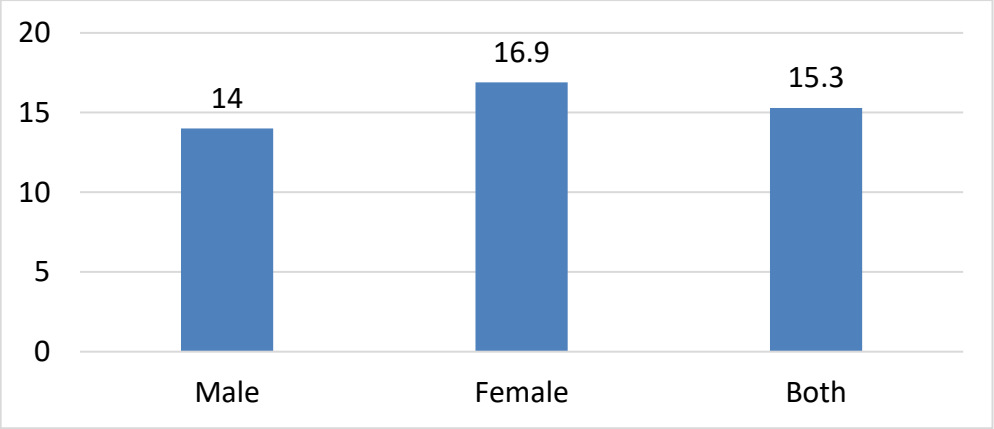


According to the prevalence values that identify VDD as a problem of public health significance as specified by the WHO for iron deficiency, the findings of this study shows that VDD is of public health significance at a 'mild' level, in 3 out of 9 provinces. All other provinces and in overall Sri Lanka, it is a 'moderate' level of public health significance. (Figure 4.17 and Table 4.6).

4.7 Zinc deficiency

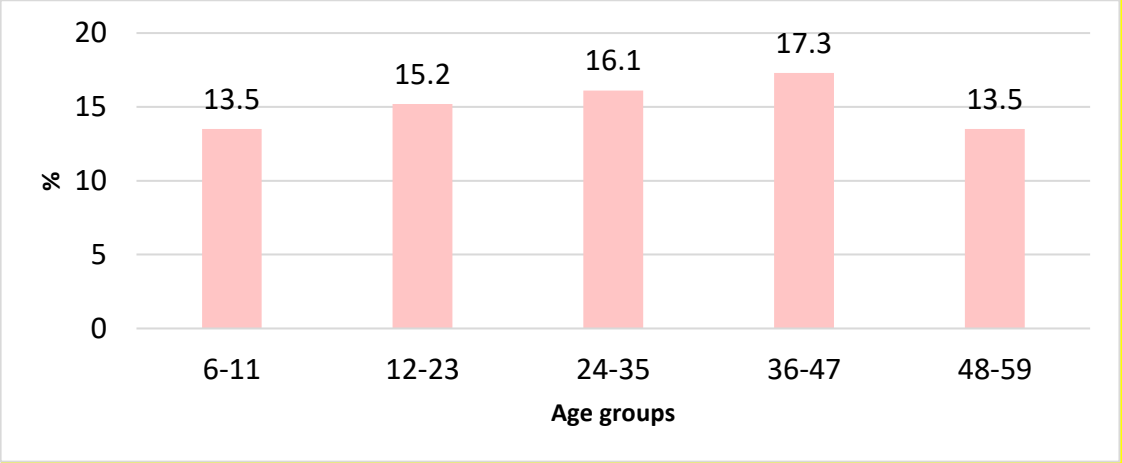
Serum zinc levels of 691 children in the age group 6–59 months were assessed using the ICP-MS. Mean zinc level was 92.2±39.1 µg/dL. Cut-off points for morning and afternoon were used separately to categorize zinc deficiency.

Figure 4.18: Prevalence of zinc deficiency in children 6-59 months of age by sex



The prevalence of zinc deficiency among children aged 6-59 months was 15.3% (Figure 4.18). There is no significant difference between boys and girls.

Figure 4.19: Prevalence of zinc deficiency by age



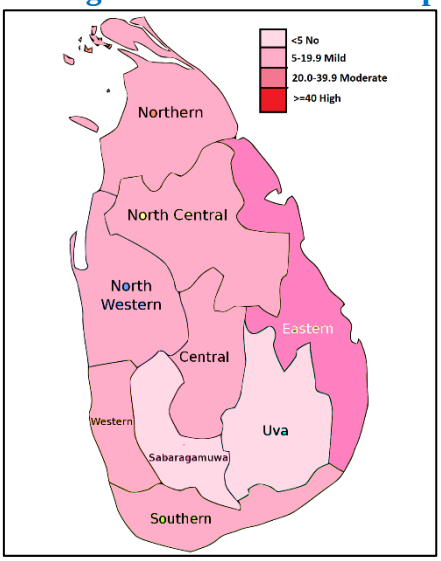
The prevalence of children with zinc deficiency was higher in the 36-47 months age category. There is an increasing prevalence of zinc deficiency with increasing age up to 36-47 age group (Figure 4.19).

Inter provincial comparisons show the prevalence to range between a low value of 1.6% in Uva province to 28.9% in Eastern province (Table 4.7). Among 9 provinces that have prevalence above the average for national level were Western, Central, Southern, Northern, Eastern, Northcentral and Northwestern provinces. The other provinces reported prevalence figures lower than that for national level. These findings should be interpreted cautiously due to low sample sizes.

Table 4.7: Prevalence of Zinc deficiency by province

Province	Zinc deficiency	N
Western	17.6	131
Central	17.9	95
Southern	15.5	103
Northern	18.3	82
Eastern	28.9	45
Northwestern	16.7	54
Northcentral	18.2	55
Uva	1.6	64
Sabaragamuwa	3.2	62
Sector		
Urban	18.7	91
Rural	14.8	541
Estate	15.3	59
Sri Lanka	**15.3**	**691**

Figure 4.20: Provincial map of Sri Lanka according to severity of Zinc deficiency



According to the prevalence values that identify zinc deficiency as a problem of public health significance as specified by the WHO for iron deficiency, the findings of this study shows that zinc deficiency is of public health significance at a 'mild' level, in 6 out of 9 provinces. It is not a public health problem in Uva and Sabaragamuwa provinces. In Eastern province, it is a 'moderate' level of public health significance. (Figure 4.20 and Table 4.7).

4.8 Iodine deficiency

Urine iodine levels of 712 children aged 6-59 months were assessed. Median iodine level was 93.8 µg/L (25^{th} percentile-75^{th} percentile: 44.4 – 173.5 µg/L). Cut-off points for iodine deficiency was 100 µg/L (Figure 4.21).

Figure 4.21: Median and mean iodine levels in children aged 6-59 months by age

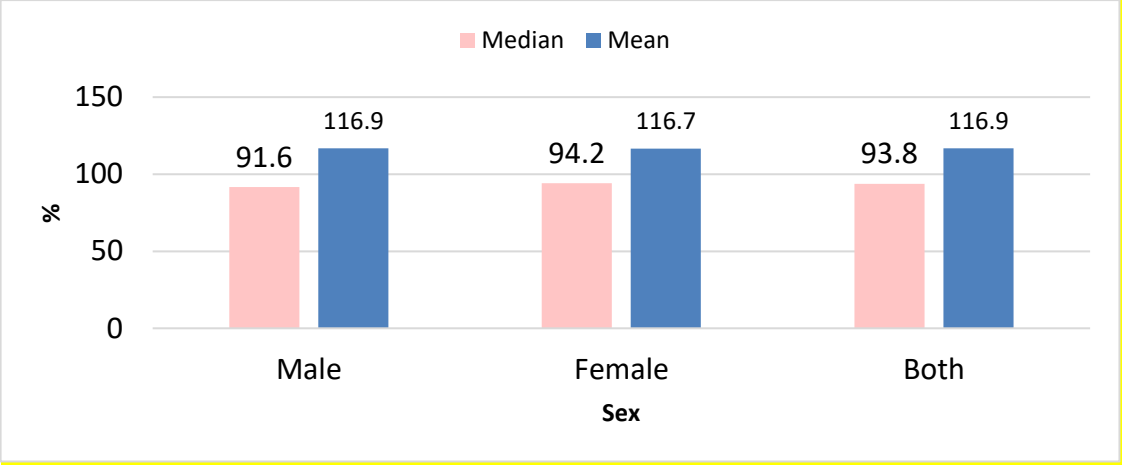
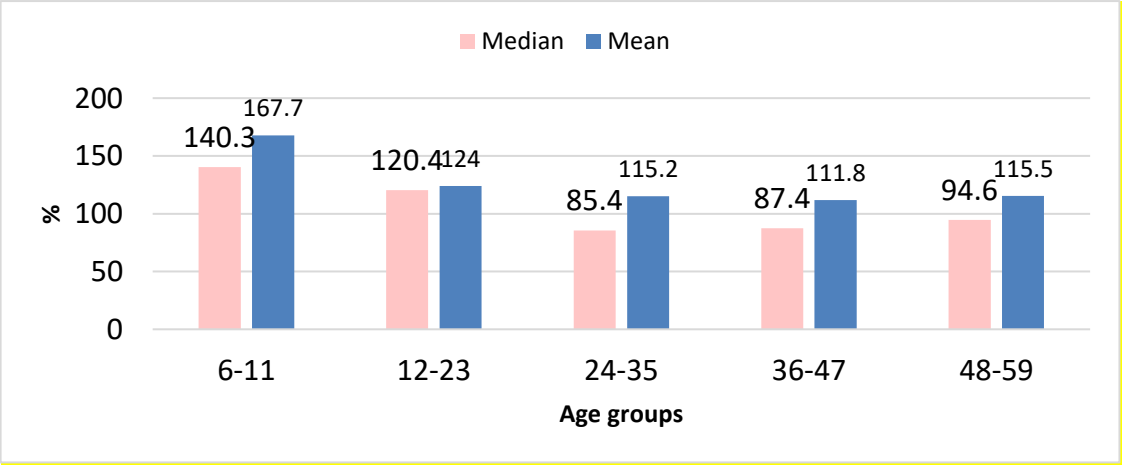


Figure 4.21 shows the sex distribution. Higher median iodine value was observed in female than male (94.2 vs 91.6 µg/L). Figure 4.22 shows the median iodine levels in relation to age groups.

Figure 4.22: Median and mean iodine levels by age

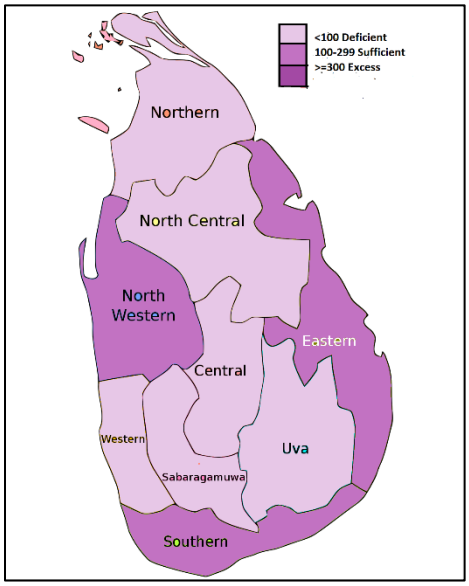


Inter provincial comparisons show the median iodine levels range between a low value of 66.4 µg/L in Western province to 131.0 µg/L in Southern province (Table 4.8). All 9 provinces except Southern, Eastern and Northwestern provinces and overall, Sri Lanka median iodine levels were lower than the optimum level of 100 µg/L. Lowest median iodine levels were observed in Urban sector (57.3 µg/L).

Table 4.8: Median iodine levels by province

Province	Median iodine level (µg/L)	Mean iodine level (µg/L)	N
Western	66.4	89.6	107
Central	92.6	114.9	104
Southern	131.0	139.4	78
Northern	90.5	116.5	95
Eastern	102.1	137.5	49
Northwestern	129.0	146.3	76
Northcentral	79.7	121.9	53
Uva	73.0	93.0	66
Sabaragamuwa	92.9	110.2	84
Sector			
Urban	57.3	89.4	79
Rural	98.6	122.9	540
Estate	78.3	105.1	93
Sri Lanka	**93.8**	**116.9**	**712**

Figure 4.23: Provincial map of Sri Lanka according to severity of Iodine deficiency



According to the prevalence values that identify iodine deficiency as a problem of public health significance as specified by the IGN/UNICEF, the findings of this study show that iodine deficiency is of public health significance in 6 out of 9 provinces. (Figure 4.23).

4.9 Breast feeding, illness, and supplements

Table 4.9 shows 61% have received MMN and 93.8% received vitamin A megadose in the last 6 months.

Table 4.9: Percentage of children 6-59 months received supplements for 6 months, breastfeeding pattern of 6-24 months and illness during last 2 weeks

Characteristics	%
Deworming last 6 months	68.0
Received MMN during last 6 months	60.7
Frequency of taking MMN	
Everyday	49.9
Every other day	13.6
2-3 days / week	11.8
Once /week	4.3
Rarely	10.1
Never	10.3
Vitamin A megadose during last 6 months	93.8
Iron supplements during last 6 months	10.3
Reason for iron supplements	
Prescribed by doctor	44.5
From the clinic	53.5
Parents	1.9
Received Thriposha within last 6 months	45.8
Sharing Thriposha with family members	84.1
Received BP-100	0.4
Children 6-24 months (n=480)	
Ever breastfed	97.0
Time of first breastfeeding	
Soon after birth	46.3
First one hour	44.4
After one hour	4.8
After 1 day	2.9
Don't know	1.7
Bottle fed	60.6
Illness during last 2 weeks	
Fever	26.8
Diarrhoea	3.2
Cough and cold	40.9
N	**1510**

4.9 Birthweight

The mean birthweight of the children was 2.9±0.5 kg. Low birth weight (<2.5 kg) prevalence was 15.9%.

CHAPTER 5: CHILDREN AGED 5-9 YEARS

A total of 892 children aged 5-9 years were recruited from the selected households and the questionnaire was administered for all of them. However, only 666 participated for anthropometry assessment and 636 were included in the biochemical assessment.

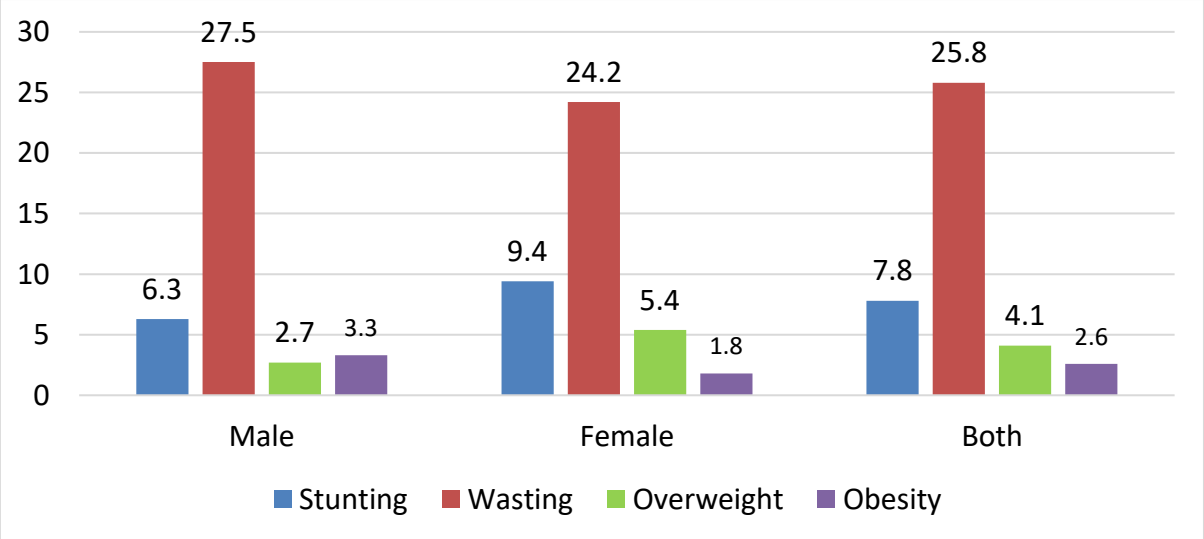
5.1 Nutrition status

Table 5.1 shows the age and sex distribution of children aged 5-9 years who were included for anthropometry (weight and height). In the overall sample, ratio of boys: girls are 1.0.

Table 5.1: Age and sex distribution of children aged 5-9 years

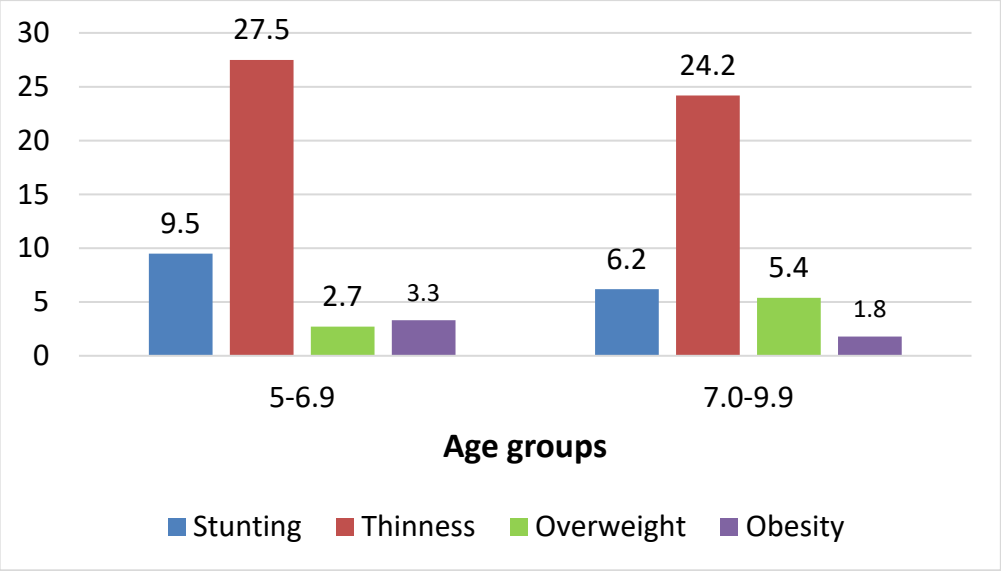
Age groups	Boys		Girls		Total		Ratio
(years)	no.	%	no.	%	no.	%	Boy: girl
5-6.9	178	53.0	150	45.3	328	49.2	1.2
7-9.9	158	45.3	181	54.7	339	50.8	0.9
Total	**336**	**49.2**	**331**	**50.8**	**667**	**100.0**	**1.0**

Figure 5.1: Stunting, wasting, overweight and obesity in children aged 5-9 years by sex



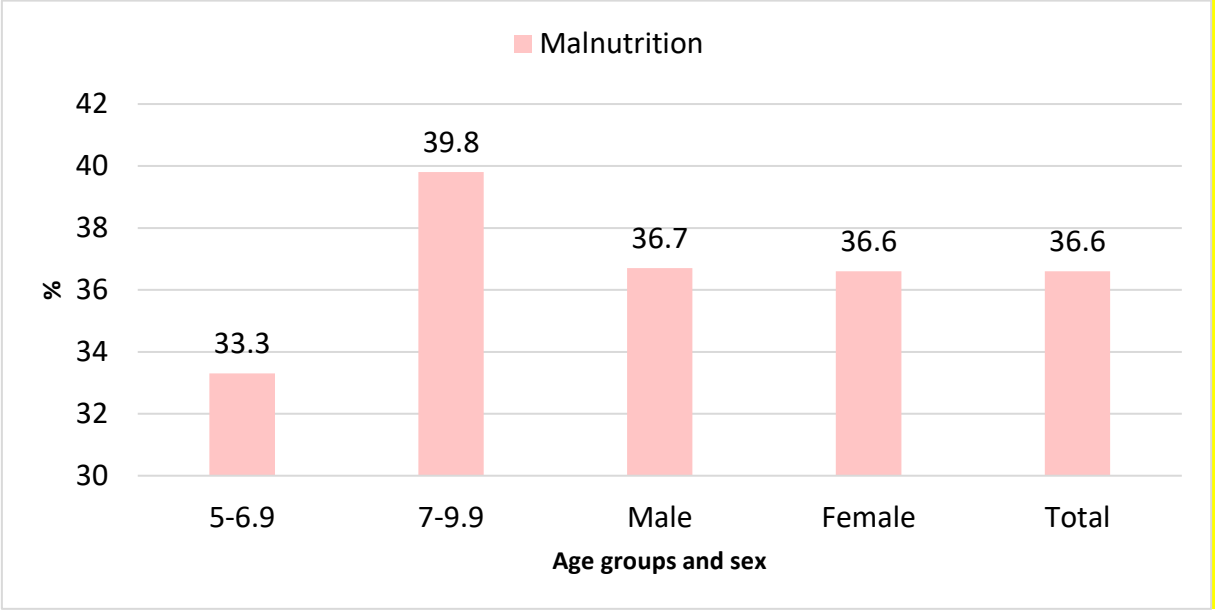
As seen in Figure 5.1, the overall prevalences of stunting, wasting, overweight and obesity were 7.8%, 25.8%, 4.1% and 2.6% respectively. Prevalence of wasting and obesity was higher among boys than girls.

Figure 5.2: Stunting, thinness, overweight and obesity in children aged 5-9 years by age



As seen in Figure 5.2, the prevalences of stunting and wasting were decreasing with the increase of age while overweight was incresing.

Figure 5.3: Prevalence of malnutrition (wasting, stunting, underweight, overweight, or more than one condition) in children 5-9 years of age



When one or more indicators of poor nutritional status (either wasting or stunting or overweight or obesity or more than one condition) is defined as "**malnutrition**". It is was observed higher prevalence among boys than girls. Figure 5.3 shows that about one third (36.6%) of children aged 5-9 years in the study sample is malnourished and highest (39.8%) among children aged 7-9.9 year group.

5.2 Anaemia

The haemoglobin (Hb) levels of 636 children in the age group 5-9 years were assessed using the point-of-care (POC) haemoglobin analyser (coulter counter) with venous blood. Mean Hb was 12.6±0.9 g/dL. The cutoff point - Hb <11.5 gms/dL and adjusted for altitudes was used to define anaemia. Mild, moderate, and severe anaemia was defined as Hb 11.0-11.4 g/dL, 8.0-10.9 g/dL and <8.0 g/dL respectively.

The prevalence of overall, mild and moderate anaemia among children aged 5-9 years was 10.2%, 6.0% and 4.2% respectively (Figure 5.4). Overall, moderate and mild anaemia was more in girls compared to boys.

Figure 5.4: Prevalence of anaemia in children 5-9 years of age

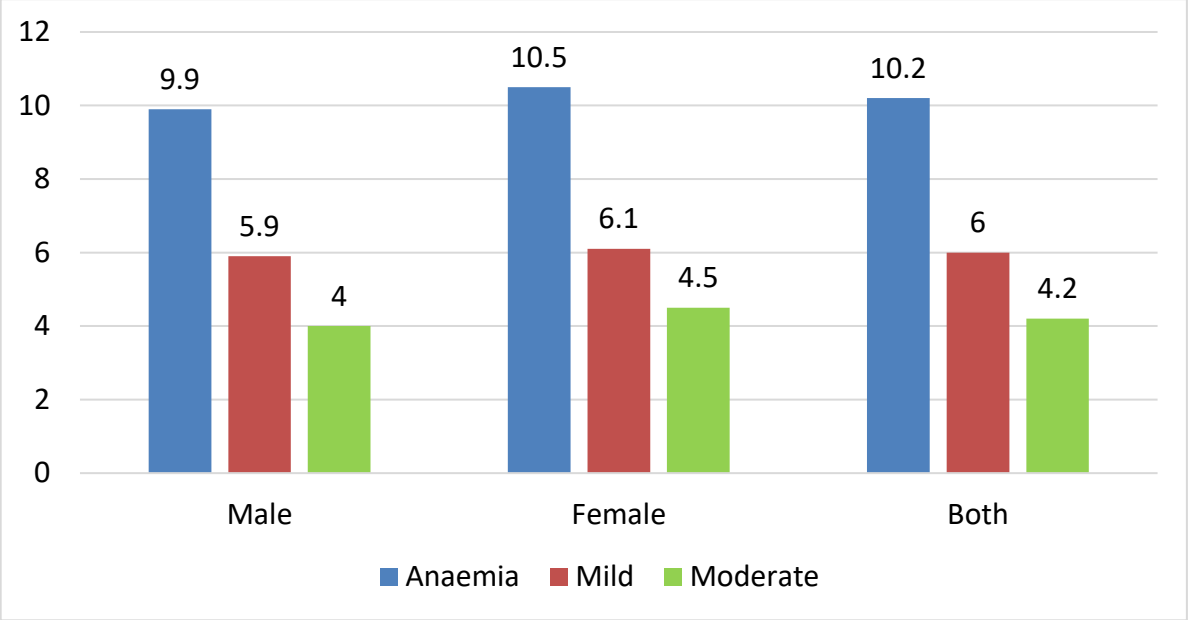
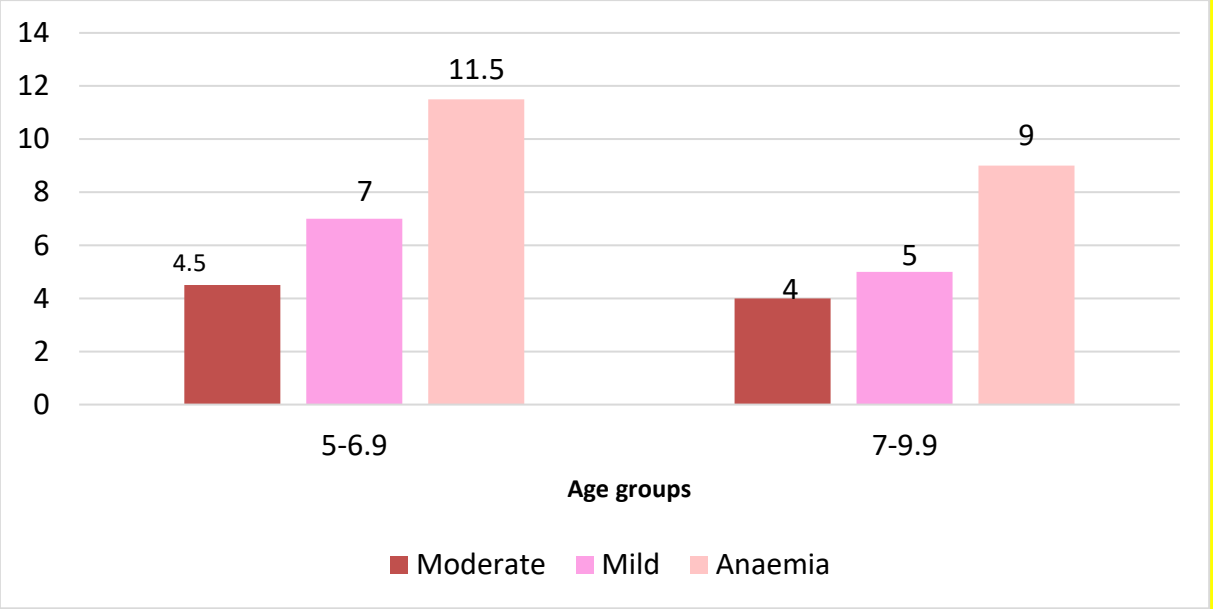


Figure 5.5: Prevalence of anaemia by age

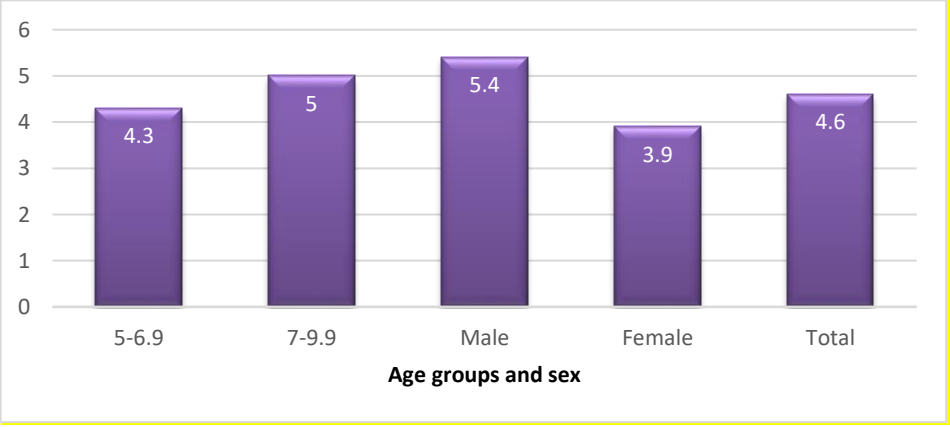


The prevalence of children with overall anaemia, moderate and mild anaemia was higher in the 5-6.9 years age category. There is a decreasing pattern of anaemia with increasing age (Figure 5.5).

5.3 Acute inflammation

Acute Reactive Phase (CRP) levels were determined to identify acute inflammation. When the CRP level was higher than 5 mg/L, it was defined as a presence of acute inflammation. In the study sample, 4.6% of children 5-9 years had acute inflammation and the highest (5.0%) among the 7-9.9 years age category. Boys had higher inflammation than girls (5.4% Vs 3.9%) (Figure 5.6).

Figure 5.6: Prevalence of acute inflammation in different age group and sex

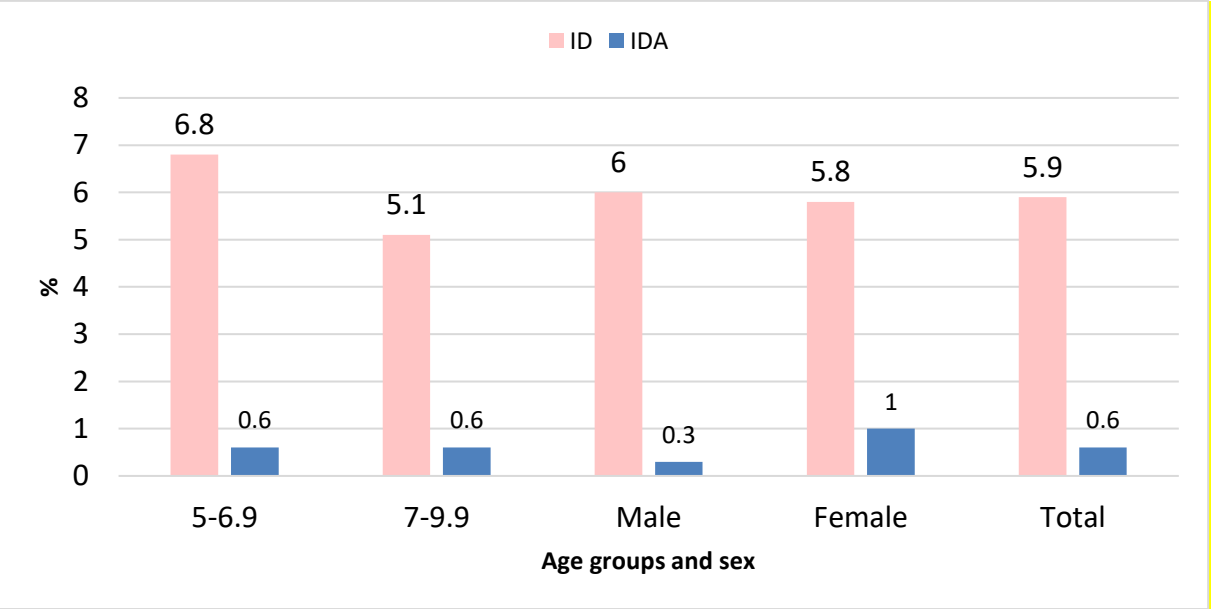


5.4 Iron deficiency and iron deficiency anaemia

Serum ferritin values of 624 children in the age group 5-9 years were assessed using the DiaSorine LIAISON XL analyser with serum. Mean ferritin level was 47.5±29.1 µg/L. The cutoff point of ferritin <15.0 µg/L when CRP is<6 mg/L and ferritin <70.0 µg/L when CRP is >5 mg/L was used to define iron deficiency (ID).

The prevalence of ID among children aged 5-9 years was 5.9% (Figure 5.7). The prevalence of ID among children aged 5-6.9 years were 6.8%. There is a decreasing pattern of ID with increasing age (Figure 5.7).

Figure 5.7: Prevalence of iron deficiency and iron deficiency anaemia by age and sex



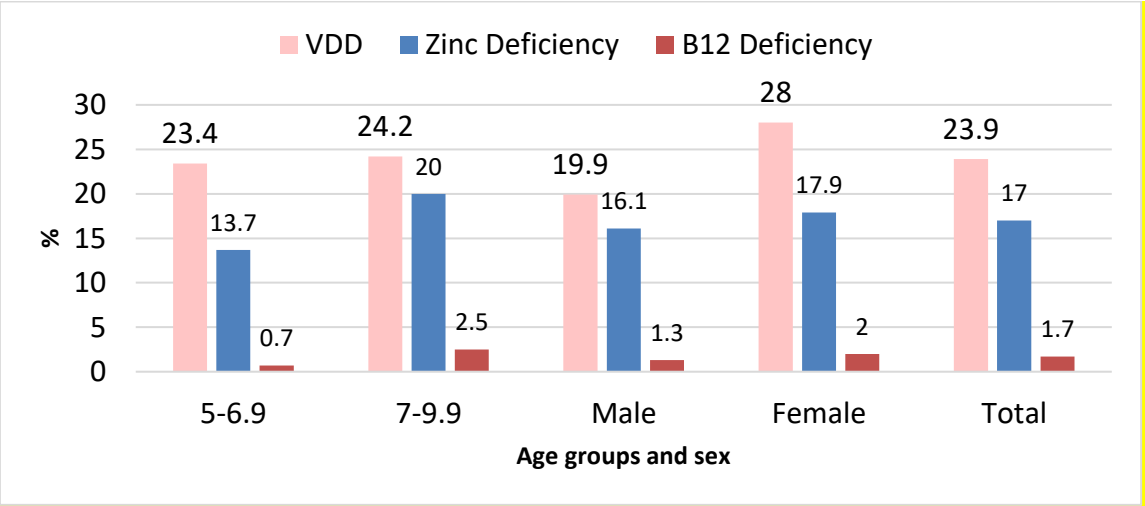
5.5 Iron deficiency anaemia

Iron deficiency anaemia (IDA) was defined as presence of both anaemia and iron deficiency. The prevalence of IDA was 0.6%. Highest prevalence of IDA was seen among female children (1.0%). There is no difference between boys and girls (Figure 5.7).

5.6 Vitamin D deficiency

Serum vitamin D levels of 306 children in the age group 5-9 years were assessed using the DiaSorine LIAISON XL analyser with serum. Mean vitamin D level was 24.7±6.9 ng/mL. The cutoff point of vitamin D <20.0 ng/mL was used to define vitamin D deficiency (VDD).

Figure 5.8: Prevalence of vitamin D, zinc, and vitamin B_{12} deficiency by age



The prevalence of VDD among children aged 5-9 years was 23.9% (Figure 5.8). VDD prevalence was higher in girls than boys (28.0% Vs 19.9%).

5.7 Vitamin B_{12} deficiency

Serum vitamin B_{12} levels of 122 children in the age group 5-9 years were assessed using the DiaSorine LIAISON XL analyser with serum. Mean vitamin B_{12} level was 398.3±155.3 pg/mL. The cutoff point of vitamin B_{12} < 160.0 pg/mL was used to define vitamin B_{12} deficiency.

The prevalence of vitamin B_{12} deficiency among children aged 5-9 years was 1.7% (Figure 5.8). There is a higher prevalence in girls than boys (2.0% Vs 1.7%). The prevalence of children with vitamin B_{12} deficiency was highest in the 7.0-9.9 years age category (1.3%).

5.8 Zinc deficiency

Mean zinc level was 97.8±38.5 µg/dL. The prevalence of zinc deficiency among children aged 5-9 years was 17.9% (Figure 5.8). There is a higher prevalence among girls than boys than (17.9 Vs 16.1%). The prevalence of children with zinc deficiency was highest in the 7.0-9.9 years age category (20.0%).

5.9 Causes of anaemia

Overall prevalence of anaemia among children aged 5-9 years was 10.2%, out of them 6.5% had IDA, 5.9% had vitamin B_{12} deficiency, 5.9% had zinc deficiency, 14.7% had vitamin D deficiency and 4.6% had acute inflammation. Other causes such as folic acid deficiency, thalassemia and chronic inflammation should be explored.

5.10 Sector difference

Table 5.2 shows the sectoral differences. VDD was highest in the estate sector.

Table 5.2: Percentage of nutrition and micronutrient deficiencies by sector

Nutrition and micronutrients	Urban	Rural	Estate	Sri Lanka
Nutrition status (n=666)				
Stunting	1.1	8.9	8.7	7.8
Wasting	17.8	27.0	27.5	25.8
Overweight	6.7	4.1	0.0	4.1
Obesity	5.6	2.2	1.4	2.6
Malnutrition	31.1	38.1	33.3	36.6
Micronutrients				
Anaemia (n=636)	10.5	11.0	4.5	10.2
Iron deficiency (n=624)	6.0	5.7	5.7	7.6
Iron deficiency anaemia (n=624)	0.0	0.6	1.5	0.6
Vitamin D deficiency (n=306)	17.4	23.1	42.6	23.9
Zinc deficiency (n=306)	15.2	17.5	15.4	17.0
Vitamin B_{12} deficiency (n=303)	0.0	2.2	0.0	1.7

5.11 Iodine deficiency

Urine iodine levels of 404 children aged 5-9 years were assessed. Median iodine level was 101.0 µg/L (25^{th} percentile-75^{th} percentile: 53.9 – 180.8). Cut-off points for iodine deficiency was 100 µg/L (Table 5.3).

Table 5.3: Median iodine levels by age, sex, and sector

Province	Median iodine level (µg/L)	Mean iodine level (µg/L)	N
Age groups in years			
5.0 – 6.9	114.1	123.7	199
7.0 – 9.9	96.9	120.0	205
Sex			
Male	113.7	127.8	205
Female	94.4	115.8	199
Sector			
Urban	69.7	92.6	47
Rural	114.5	128.2	333
Estate	63.2	91.6	24
Sri Lanka	**101.0**	**121.8**	**404**

5.12 Illness and taking supplements.

Table 5.4 shows 18.1% has received iron supplements from the school during the last year and 61.2% were dewormed during the last 6 months.

Table 5.4: Percentage of children 5-9 years received supplements for 6 months, and illness during last 2 weeks

Characteristics	%
Deworming last 6 months	61.2
Received iron folate from school during last one year	18.1
Frequency of receiving iron folate from school	
Weekly for 6 months	30.7
Weekly for 4-5 months	5.0
Weekly for 2-3 months	15.8
Weekly for 1 month	13.9
Intermittently	9.9
Rarely	24.8
Other iron supplements during last 6 months	7.5
Reason for giving iron supplements	
Prescribed by doctor	40.5
From the clinic	26.2
Parents	28.6
Other	4.8
Usually take breakfast before going to school	73.5
Taken breakfast or snack to school	88.7
Usually receive school meal	22.4
Frequency of receiving school meal	
Everyday	82.4
3-4 days per week	7.2
1-2 days per week	4.0
Varied	2.4
Rarely	4.0
Illness during last 2 weeks	
Fever	22.5
Diarrhoea	1.5
Cough and cold	37.6
Ever had COVID infection	4.1

CHAPTER 6: CHILDREN AGED 10-17 YEARS

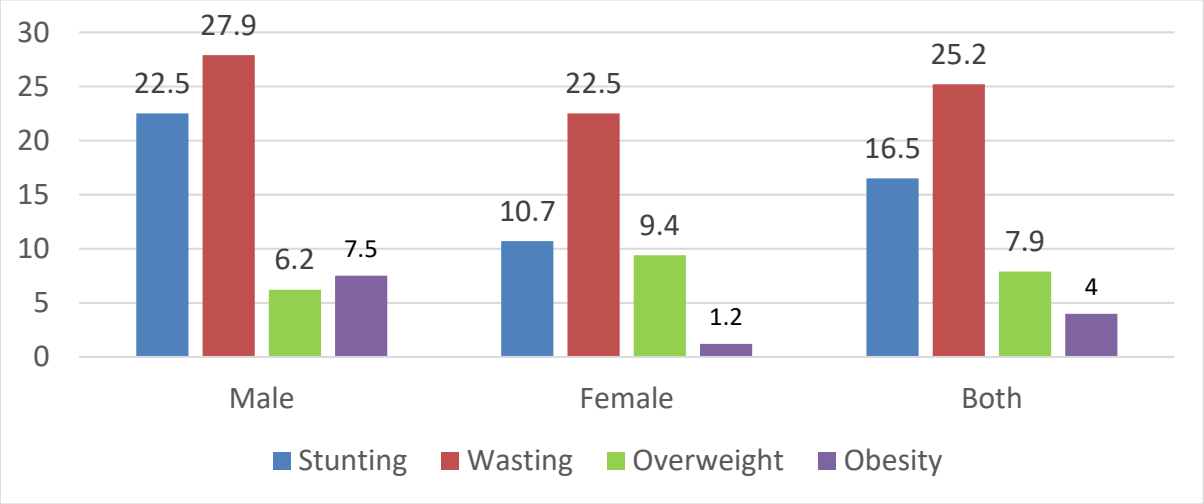
6.1 Nutrition status

Table 6.1 shows the age and sex distribution of the children aged 10 - 17 years who were included for anthropometry (weight and height). In the overall sample, boys: girls' ratio is 0.98.

Table 6.1: Age and sex distribution of children aged 10-17 years

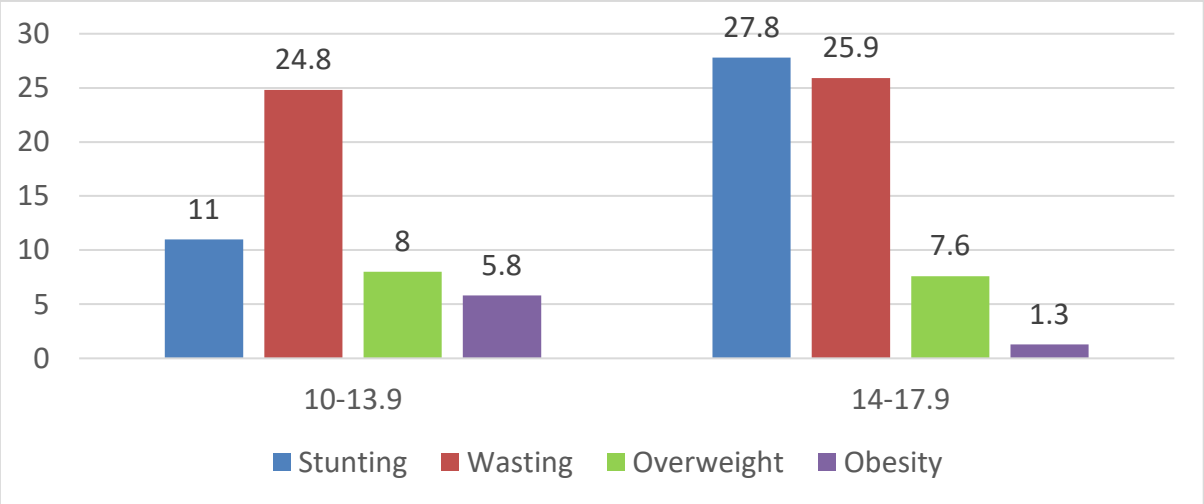
	Boys		Girls		Total	
AGE (years)	**no.**	**%**	**no.**	**%**	**no.**	**%**
10-13.9	155	47.3	173	52.7	326	**67.4**
14-17.9	85	53.5	74	46.5	158	**32.6**
Total	**240**	**49.6**	**244**	**50.7**	**484**	**100.0**

Figure 6.1: Stunting, thinness, overweight and obesity in children aged 10-17 years



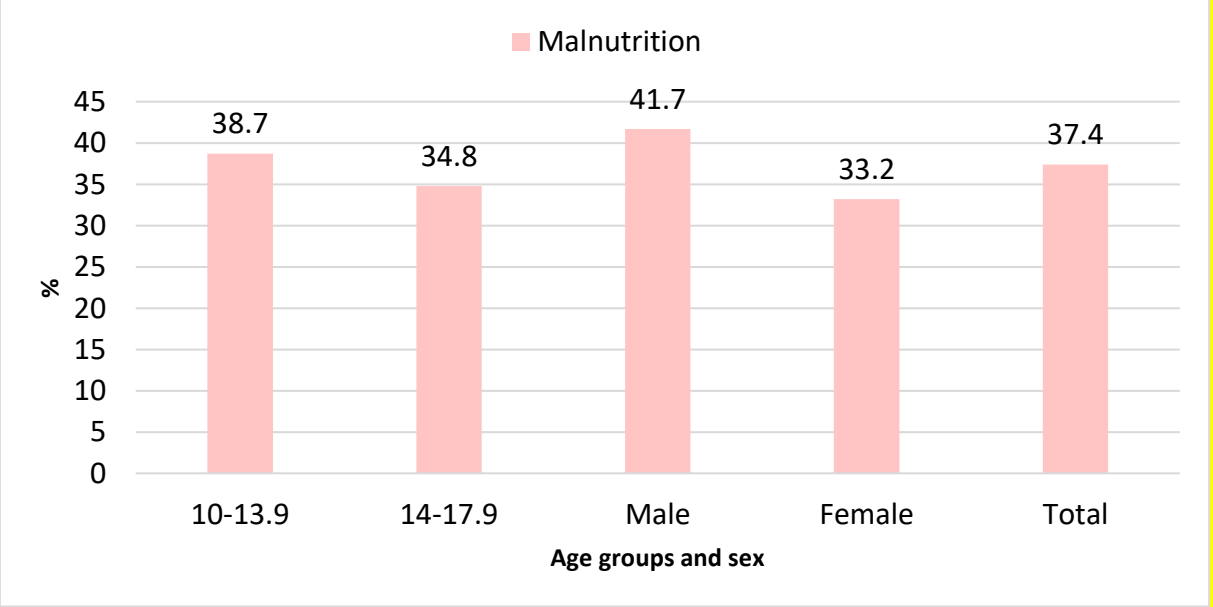
As seen in Figure 6.1, the overall prevalences of stunting, wasting, overweight and obesity were 16.5%, 25.2%, 7.9% and 4.0% respectively. Prevalence of stunting, wasting and obesity was more prevalent among boys than girls, but there were more overweight girls.

Figure 6.2: Stunting, thinness, overweight and obesity in children aged 10-17 years by age



As seen in Figure 6.2, the overall prevalences of stunting and wasting were higher among 14-17.9 age group than 10-13.9 age group except overweight and obesity. However, this should be interpreted cautiously due to low sample size.

Figure 6.3: Prevalence of malnutrition (wasting, stunting, underweight, overweight, or more than one condition) in children 10-17 years of age



When one or more indicators of poor nutritional status (either wasting or stunting or overweight or obesity or more than one condition) is defined as "**malnutrition**". It is was observed higher prevalence among boys than girls. Figure 6.3 shows 37.4% of children aged 10-17 years in the study sample was malnourished and highest (38.7%) among children aged 10-13.9 year group and among boys (41.7%).

6.2 Anaemia

The haemoglobin (Hb) levels of 468 children in the age group 10-17 years were assessed using the point-of-care (POC) haemoglobin analyser (coulter counter) with venous blood. Mean Hb was 12.8±1.1 g/dL. The cutoff point - Hb <11.5 gms/dL for <12 years of age, 12 g/dL for ≥ 12 years of age and 13 g/dL for ≥ 15 years of age males, which was adjusted for altitudes and used to define anaemia. Mild, moderate, and severe anaemia was defined as Hb 11.0-11.4 for < 12 years of age or 11.0-11.9 g/dL for ≥ 12 years of age, 8.0-10.9 g/dL and <8.0 g/dL respectively.

The prevalence of overall, mild and moderate anaemia among children aged 10-17 years were 18.3%, 10.3% and 6.7% respectively (Figure 6.4). Overall and mild anaemia was more in boys compared to girls.

Figure 6.4: Prevalence of anaemia in children 10-17 years of age

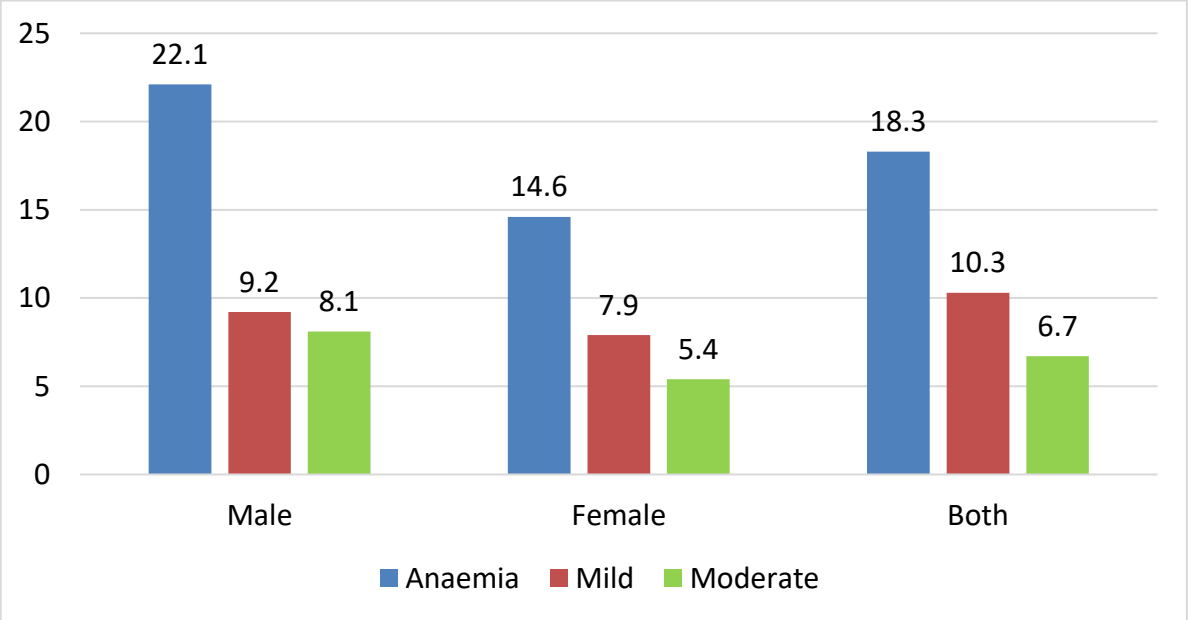
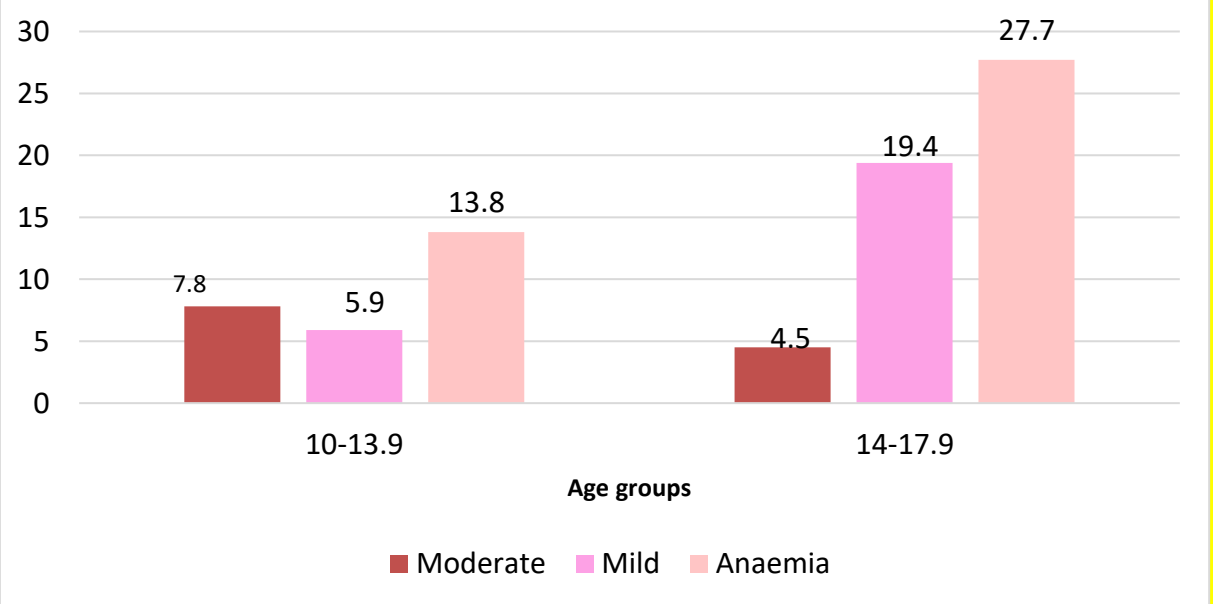


Figure 6.5: Prevalence of anaemia by age

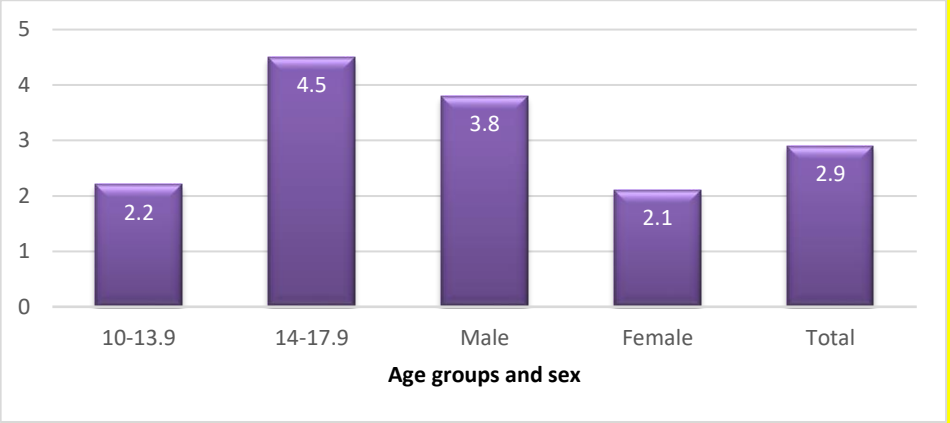


The prevalence of children with overall anaemia, and mild anaemia was higher in the 14-17.9 years age category (Figure 6.5).

6.3 Acute inflammation

Acute Reactive Phase (CRP) levels were determined in 468 children aged 10-17 years to identify acute inflammation. When the CRP level was higher than 5 mg/L, it was defined as a presence of acute inflammation. In the study sample, 2.9% of children 10-17 years had acute inflammation and the highest (4.5%) among the 14-17.9 years age category. Boys had higher inflammation than girls (3.8% Vs 2.1%) (Figure 6.6).

Figure 6.6: Prevalence of acute inflammation in different age group and sex



6.4 Iron deficiency and iron deficiency anaemia

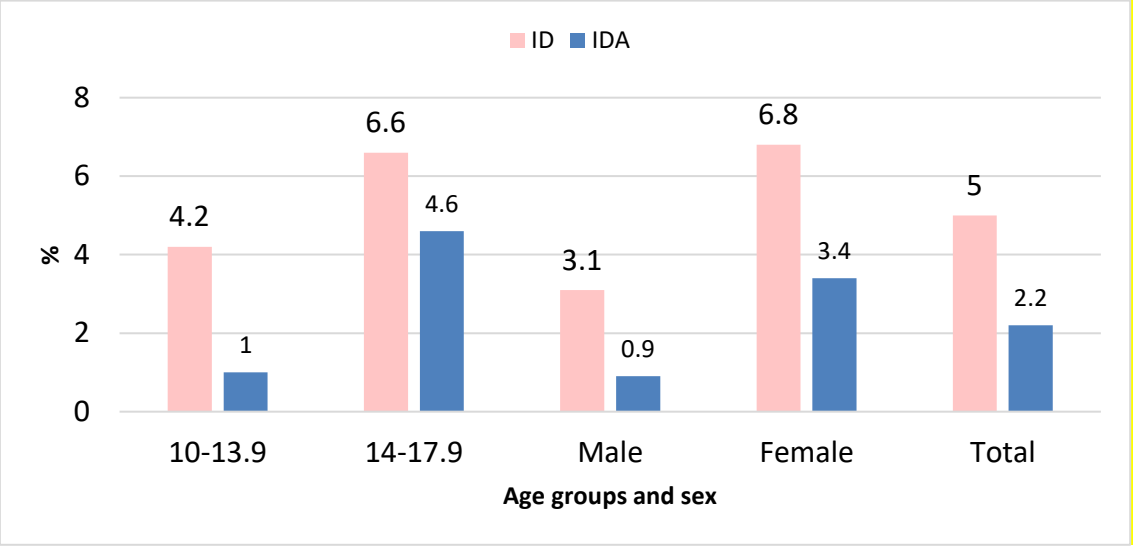
Serum ferritin values of 463 children in the age group 10-17 years were assessed using the DiaSorine LIAISON XL analyser with serum. Mean ferritin level was 50.1±39.8 µg/L. The cutoff point of ferritin <15.0 µg/L when CRP is<6 mg/L and ferritin <70.0 µg/L when CRP is >5 mg/L was used to define iron deficiency (ID).

The prevalence of ID among children aged 10-17 years was 5.0% (Figure 6.7). There is a higher ID prevalence among girls than boys (6.8% Vs 3.1%).

The prevalence of children with ID was highest in the 14-17.9 years age category (Figure 6.7).

Iron deficiency anaemia (IDA) was defined as presence of both anaemia and iron deficiency. The prevalence of IDA was 2.2%. The highest prevalence of IDA was seen among children of 14-17.9 years old children (6.6%) and among girls (3.4%) (Figure 6.7).

Figure 6.7: Prevalence of iron deficiency and iron deficiency anaemia by age and sex



6.5 Causes of anaemia

Overall prevalence of anaemia among children aged 10-17 years was 18.3%, out of them 13.3% had ID, and 5.7% had acute inflammation. Other causes such as folic acid deficiency, thalassemia and chronic inflammation should be explored.

6.6 Sector difference

Table 6.2 shows the sectoral differences. The highest prevalence of ID was observed in urban sector and IDA in estate sector.

Table 6.2: Percentage of nutrition and micronutrient deficiencies by sector

Nutrition and micronutrients	Urban	Rural	Estate	Sri Lanka
Nutrition status (n=484)				
Stunting	22.5	15.7	13.6	16.5
Wasting	21.1	24.4	38.6	25.2
Overweight	7.0	8.1	6.8	7.9
Obesity	2.8	4.9	2.3	4.3
Malnutrition	31.0	37.4	47.7	37.4
Micronutrients				
Anaemia (n=475)	20.0	18.0	18.6	18.3
Iron deficiency (n=463)	4.3	5.1	4.8	5.0
Iron deficiency anaemia (n=463)	2.9	1.7	4.8	2.2

6.7 Iodine deficiency

Urine iodine levels of 402 children aged 10-17 years were assessed. Median iodine level was 90.5 µg/L (25^{th} - 75^{th} percentile: 47.5-161.4). Cut-off points for iodine deficiency was 100 µg/L (Table 6.3).

Table 6.3: Median iodine levels by age, sex, and sector

Province	Median iodine level (µg/L)	Mean iodine level (µg/L)	N
Age groups in years			
10-13.9	95.8	112.3	269
14-17.9	85.3	113.7	133
Sex			
Male	86.5	119.6	203
Female	106.9	112.1	199
Sector			
Urban	82.4	97.5	58
Rural	97.8	116.2	308
Estate	68.2	100.5	36
Sri Lanka	**90.5**	**112.1**	**402**

6.8 Illness and taking supplements

Table 6.4 shows 27.8% has received iron supplements from the school during the last year.

Table 6.4: Percentage of children 10-17 years received supplements for 6 months, and illness during last 2 weeks.

Characteristics	%
Received iron folate from school during last one year	27.8
Frequency of receiving iron folate from school	
Weekly for 6 months	22.1
Weekly for 4-5 months	6.6
Weekly for 2-3 months	13.3
Weekly for 1 month	13.7
Intermittently	15.5
Rarely	28.8
Other iron supplements during last 6 months	3.8
Reason for giving iron supplements	
Prescribed by doctor	48.4
From the clinic	9.7
Parents	35.5
Other	6.5
Illness during last 2 weeks	
Fever	12.3
Diarrhoea	1.1
Cough and cold	4.9
Ever had COVID infection	6.1
Taken COVID injection	
1 dose	55.2
2 doses	33.5
3 doses	11.1
4 doses	0.1

CHAPTER 7: PREGNANT WOMEN

7.1 Nutrition status

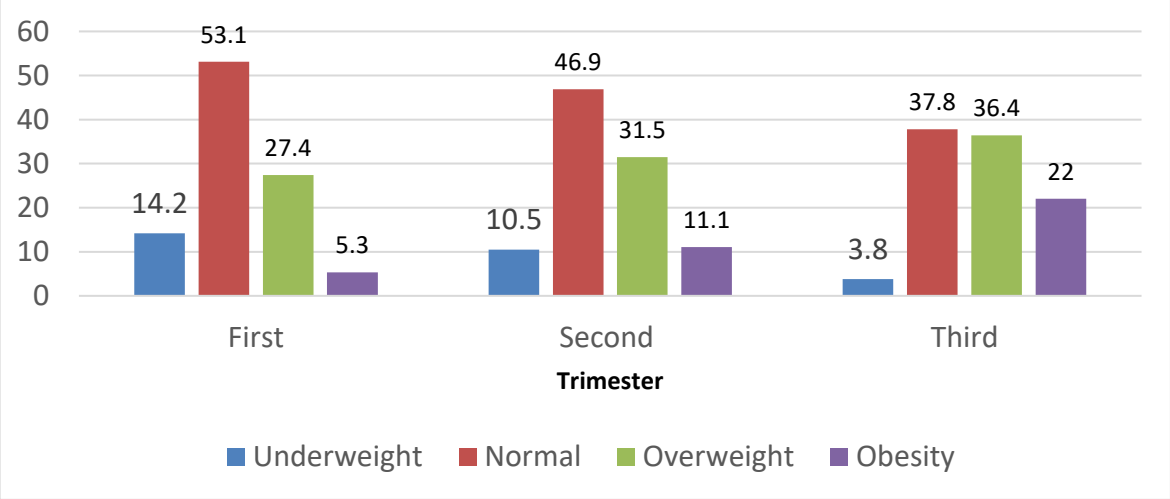
Table 7.1 shows the age distribution of the pregnant women included for anthropometry (weight and height).

Table 7.1: Age distribution of pregnant women

AGE (years)	no.	%
< 25	201	18.3
25-29	357	32.6
30-34	351	32.0
≥35	187	17.1
Total	**1096**	**100.0**

As seen in Figure 7.1, half of pregnant women are of normal weight during the first trimester. Around 14% of pregnant women are underweight, 27.4% were overweight and 5.3% were obese during the first trimester. BMI distribution within other trimesters were also provided.

Figure 7.1: Underweight, overweight and obesity of pregnant women



7.2 Anaemia

The haemoglobin (Hb) levels of 1086 pregnant women were assessed using the Erba elite 3-part hematology analyser with venous blood. Mean Hb was 11.9±1.1 g/dL. The cutoff point - Hb <11.0 gms/dL and adjusted for altitudes was used to define anaemia. Hb<10.5 g/dL was taken as the cut-off for pregnant women in the second trimester. Mild, moderate, and severe anaemia was defined as Hb 10.0-10.9 g/dL, 7.0-9.9 g/dL and <7g/dL respectively.

The prevalence of overall anaemia, mild and moderate anaemia among pregnant women was 15.0% (CI:12.8-17.1%), 10.7% (CI:8.9-12.6%) and 4.3% (CI:3.1-5.5%) respectively (Figure

7.2). Severe anaemic pregnant women were not found in the study sample. Overall prevalence of anaemia is lower than the 2012 national prevalence (33%).

Figure 7.2: Prevalence of anaemia in pregnant women

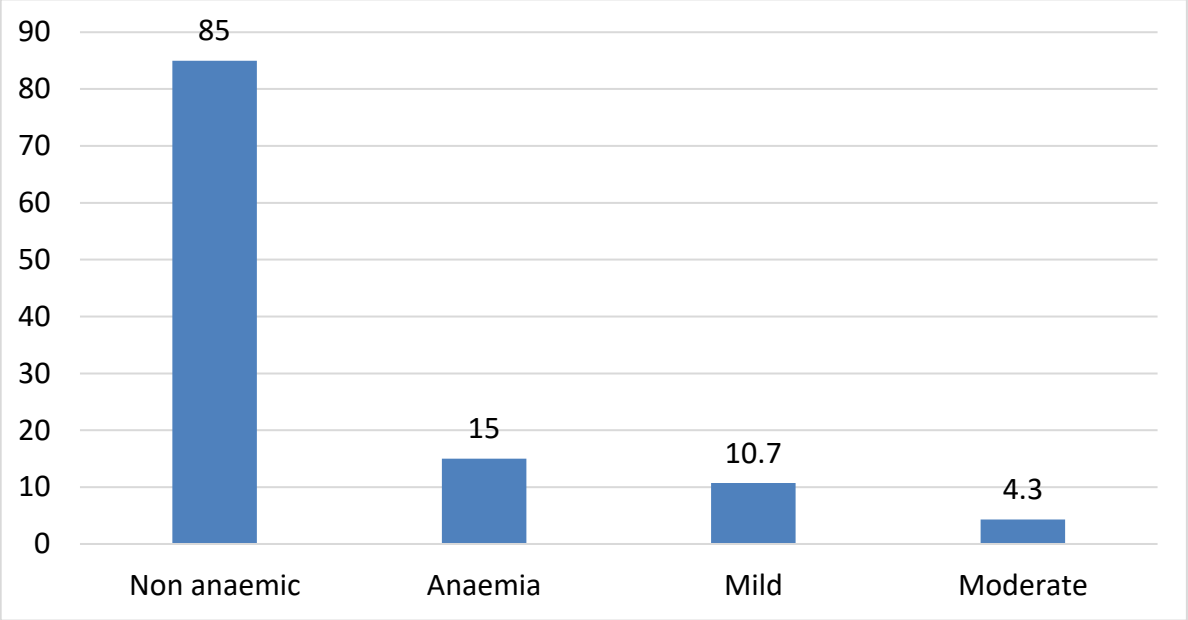
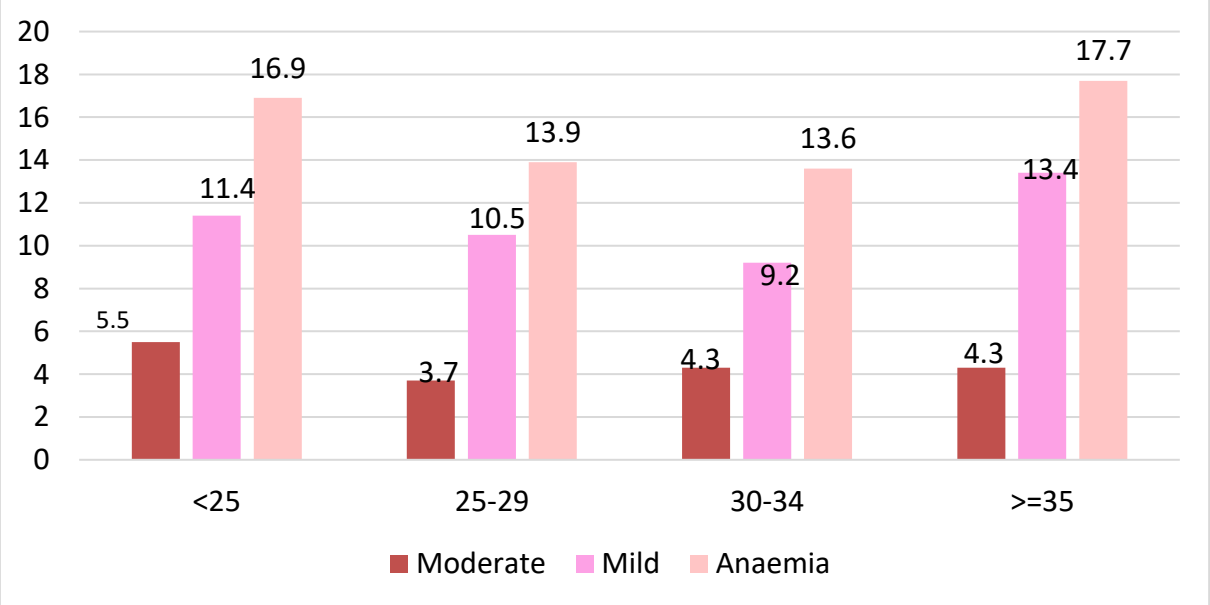
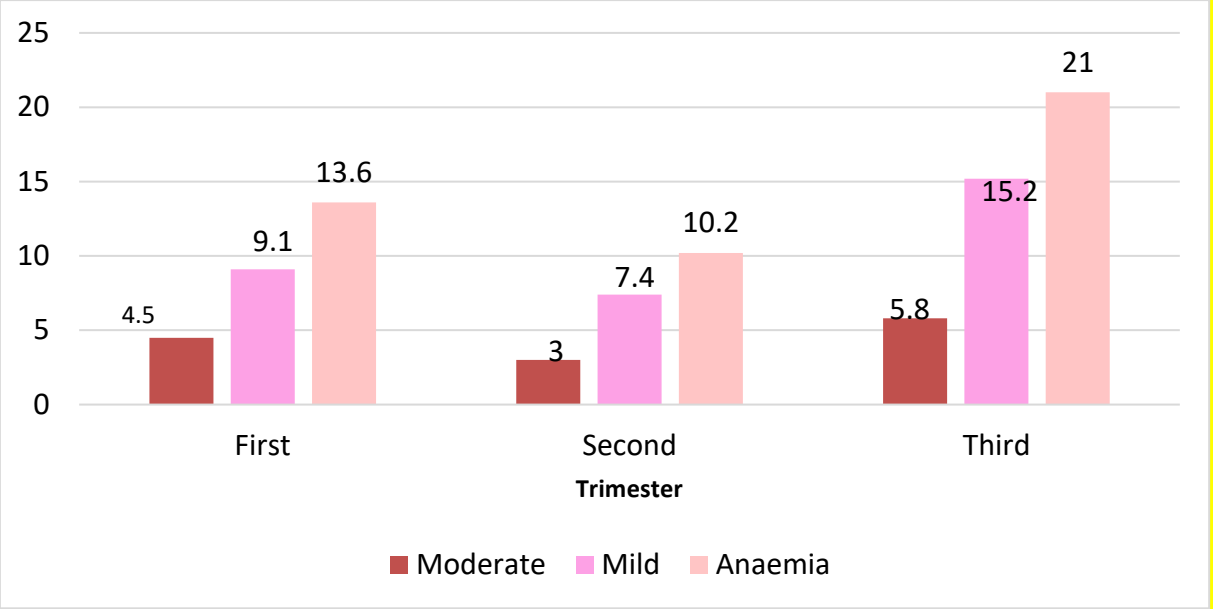


Figure 7.3: Prevalence of anaemia by age in pregnant women



The prevalence of overall anaemia, moderate and mild anaemia was higher in the <25 years and >=35 years age categories. There is a decreasing trend of anaemia with increasing age from 16.9% to 13.6% until 35 years of age (Figure 7.3).

Figure 7.4: Prevalence of anaemia by trimesters of pregnant women



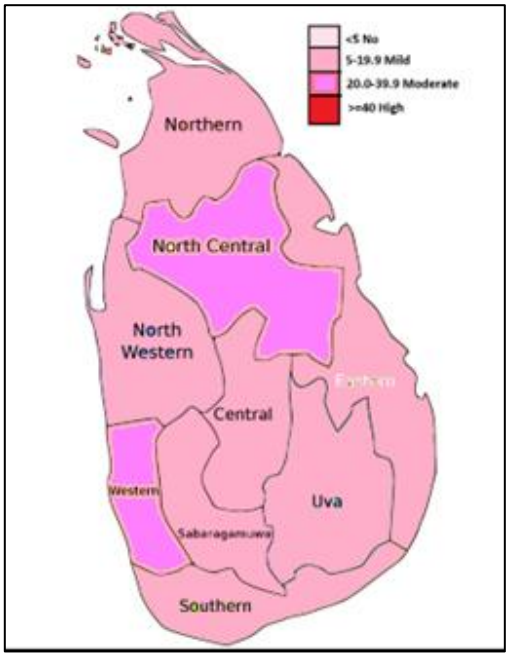
The prevalence of overall anaemia, moderate and mild anaemia was highest in the third trimester. (Figure 7.4).

Table 7.2: Prevalence of anaemia by province and sector in pregnant women

	Overall anaemia	Moderate anaemia	Mild anaemia	Non anaemic	N
Province					
Western	21.0	6.6	14.4	79.0	181
Central	9.2	0.8	8.4	90.8	131
Southern	15.6	5.4	10.2	84.4	167
Northern	15.3	4.2	11.0	84.7	118
Eastern	13.4	5.5	7.9	86.6	127
Northwestern	17.2	2.6	14.7	82.8	116
Northcentral	22.4	7.5	14.9	77.6	67
Uva	10.5	4.2	6.3	89.5	95
Sabaragamuwa	8.3	1.2	8.3	91.7	84
Sector					
Urban	19.9	7.7	12.2	80.1	181
Rural	14.4	3.8	10.7	85.6	819
Estate	10.5	2.3	8.1	89.5	86
Sri Lanka	**15.0**	**4.3**	**10.7**	**85.0**	**1086**

Inter provincial comparisons show the prevalence to range between a low value of 8.3% in Sabaragamuwa province to 22.4% in Northcentral province (Table 7.2). Among 9 provinces that have prevalence below the average for national level were Central, Eastern, Uva and Sabaragamuwa provinces. The other provinces reported prevalence figures higher than that for national level. The highest prevalence of anaemia is found in the urban sector (19.9%).

Figure 7.5: Provincial map of Sri Lanka according to severity of anaemia

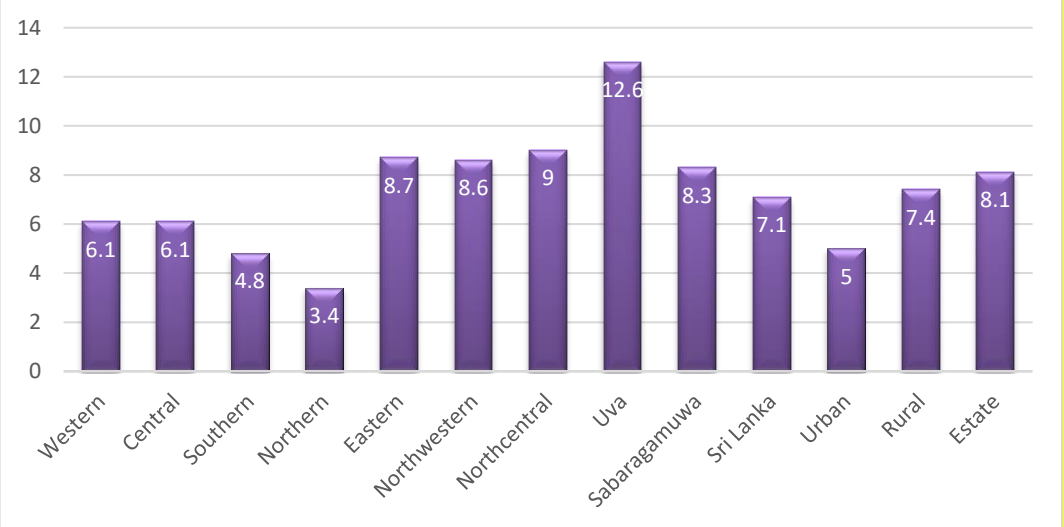


According to the prevalence values that identify anaemia as a problem of public health significance as specified by the WHO, the findings of this study shows that anaemia is of public health significance at a 'mild' level, in all provinces except Western and North Central provinces (Figure 7.5 and Table 7.2).

7.3 Acute inflammation

Acute Reactive Phase (CRP) levels were determined to identify acute infections. When the CRP level was higher than 5 mg/L, it was defined as a presence of acute inflammation. In the study sample, 7.1% of pregnant women had acute inflammation and varied from 3.4% in Northern province to 12.6% in Uva province (Figure 7.6). The highest level was observed in the estate sector (8.1%).

Figure 7.6: Prevalence of acute inflammation in different province (n=1086)



7.4 Iron deficiency

Serum ferritin values of 1065 pregnant women are assessed. Mean ferritin level was 48.7±39.0 µg/L. The cutoff point of ferritin <15.0 µg/L when CRP is<5 mg/L and ferritin <70.0 µg/L when CRP is >5 mg/L was used to define iron deficiency (ID).

The prevalence of ID among pregnant women was 11.0% (Figure 7.7). There is an increasing trend with increasing trimester from 8.4% to 12.8%. The prevalence of ID is lower than the 2012 national prevalence (33.6%).

Figure 7.7: Prevalence of iron deficiency in pregnant women by trimester

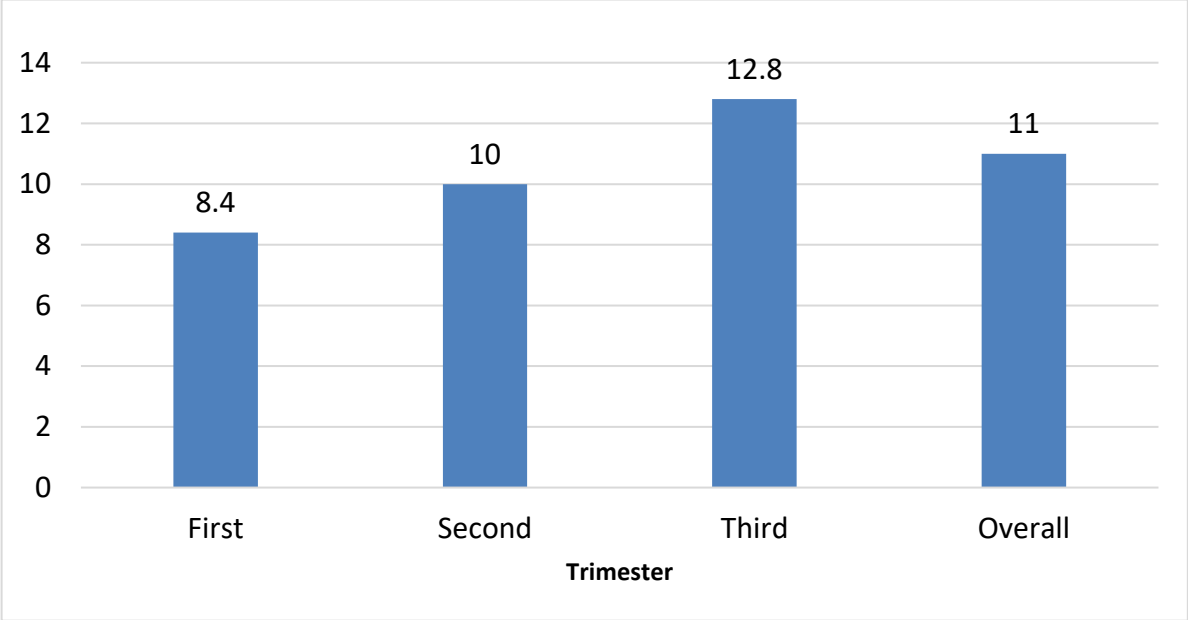
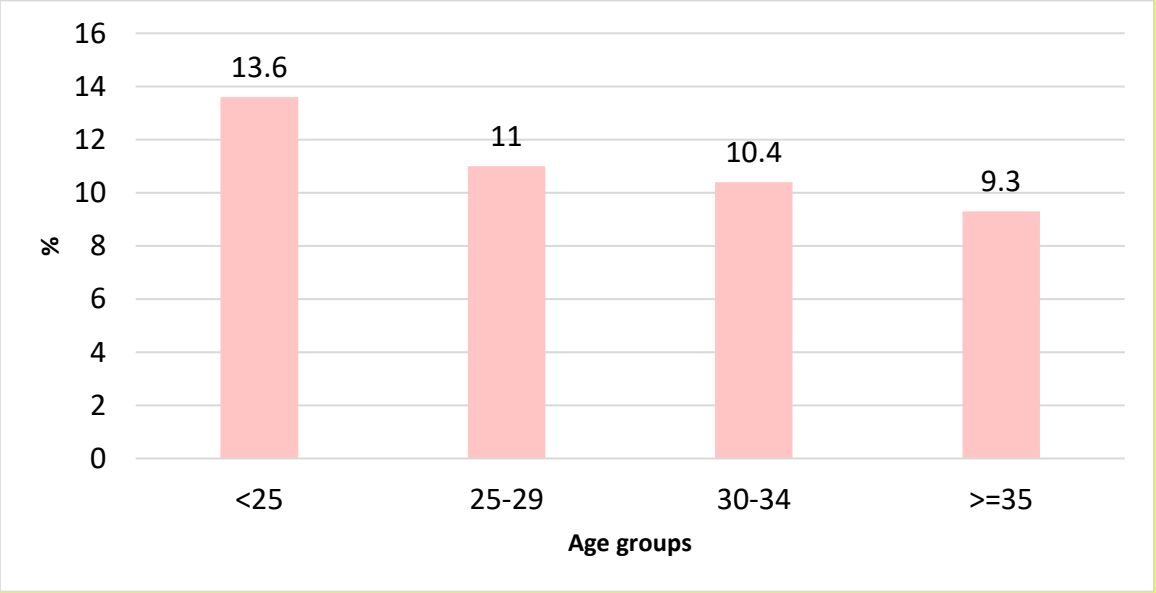


Figure 7.8: Prevalence of iron deficiency (ID) by age



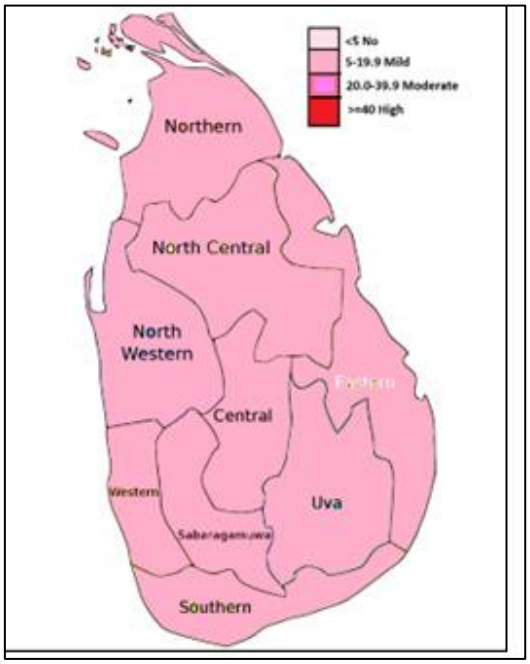
The prevalence of pregnant women with ID was higher in the <25 years age category. There is a decreasing trend of ID with increasing age from 13.6% to 9.3% (Figure 7.8).

Inter provincial comparisons show the prevalence to range between a low value of 5.4% in Uva province to 17.5% in Northcentral province (Table 7.3). Among 9 provinces that have prevalence higher the average for national level were Western, Eastern, Northwestern, Northcentral and Sabaragamuwa provinces. The other provinces reported prevalence figures lower than that for national level. Highest prevalence was observed in urban sector (12.6%).

Table 7.3: Prevalence of iron deficiency by province and sector

Province	ID	N
Western	14.0	178
Central	10.8	130
Southern	5.5	163
Northern	8.6	116
Eastern	14.3	126
Northwestern	12.2	115
Northcentral	17.5	63
Uva	5.4	92
Sabaragamuwa	13.4	82
Sector		
Urban	12.6	174
Rural	10.5	807
Estate	11.9	84
Sri Lanka	**11.0**	**1065**

Figure 7.9: Provincial map of Sri Lanka according to severity of iron deficiency



According to the prevalence values that identify ID as a problem of public health significance as specified by the WHO, the findings of this study shows that ID is of public health significance at a 'mild' level, in all 9 provinces and in overall Sri Lanka. (Figure 7.9).

7.5 Iron deficiency anaemia

Iron deficiency anaemia (IDA) was defined as presence of both anaemia and iron deficiency. Highest prevalence of IDA was seen among the pregnant women less than 25 years, in the third trimester, living in estate sector, residing in Western province. Inter provincial comparisons show all the provinces had IDA below 5% except in Western province (Table 7.4).

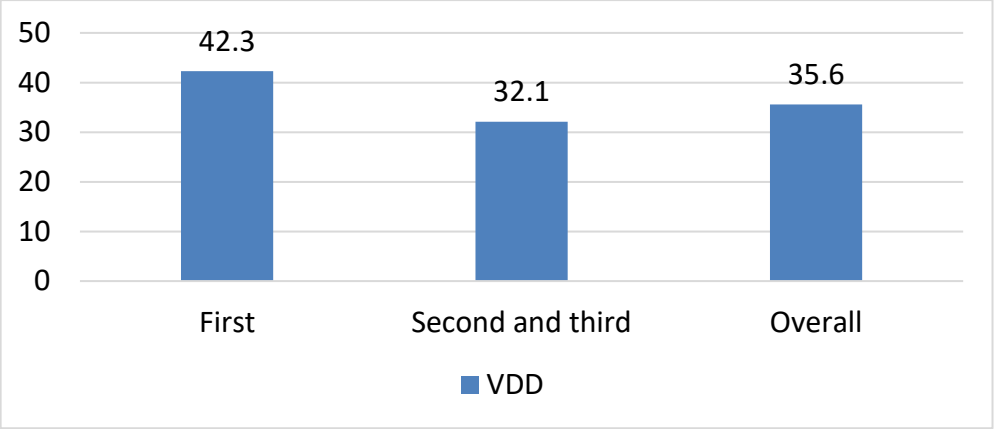
Table 7.4: Prevalence of iron deficiency anaemia (IDA) among children aged 6-59 months by sex, age and provinces

Background characteristic	No	% of pregnant women with IDA
Age in years		
<25	199	3.5
25-29	345	2.0
30-34	338	2.4
≥ 35	183	2.7
Trimester		
First	107	0.9
Second	522	2.1
Third	436	3.4
Sector		
Urban	174	5.2
Rural	807	1.6
Estate	84	6.0
Province		
Western	178	5.1
Central	130	2.3
Southern	163	1.2
Northern	116	1.7
Eastern	126	4.0
Northwestern	115	0.9
Northcentral	63	3.2
Uva	92	0.0
Sabaragamuwa	82	3.7
Sri Lanka	**1065**	**2.5**

7.6 Vitamin D deficiency

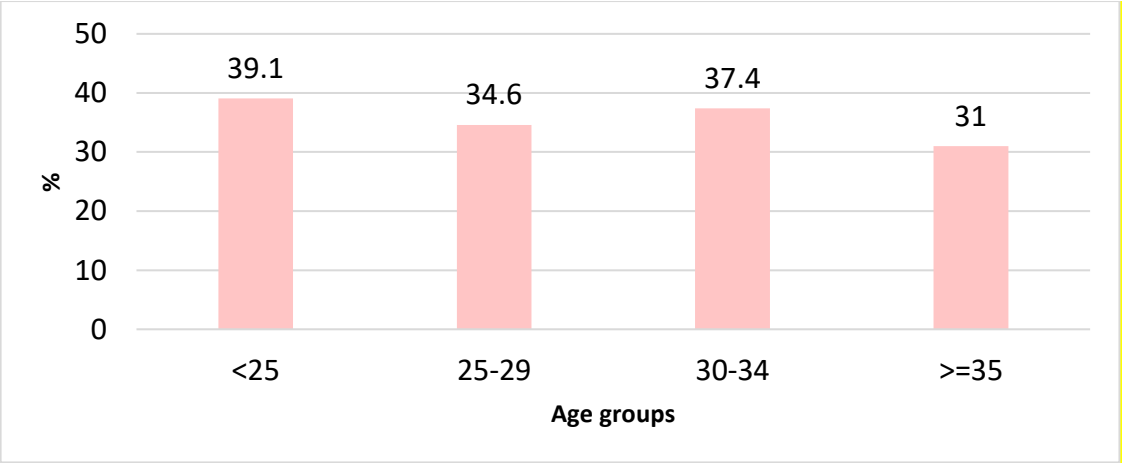
Serum vitamin D levels of 317 pregnant women was assessed. Mean vitamin D level was 21.7±5.7 ng/mL. The cutoff point of vitamin D <20.0 ng/mL was used to define vitamin D deficiency (VDD).

Figure 7.10: Prevalence of vitamin D deficiency in pregnant women by trimester



The prevalence of VDD among pregnant women was 35.6% (Figure 7.10). VDD in pregnant women of first trimester was 42.3% indicating high prevalence of VDD in the normal population.

Figure 7.11: Prevalence (%) of vitamin D deficiency by age



The prevalence of pregnant women with VDD was higher in the <25 years age category. There is no consistent pattern of VDD with increasing age (Figure 7.11).

Highest prevalence of VDD was observed in the estate sector (Table 7.5).

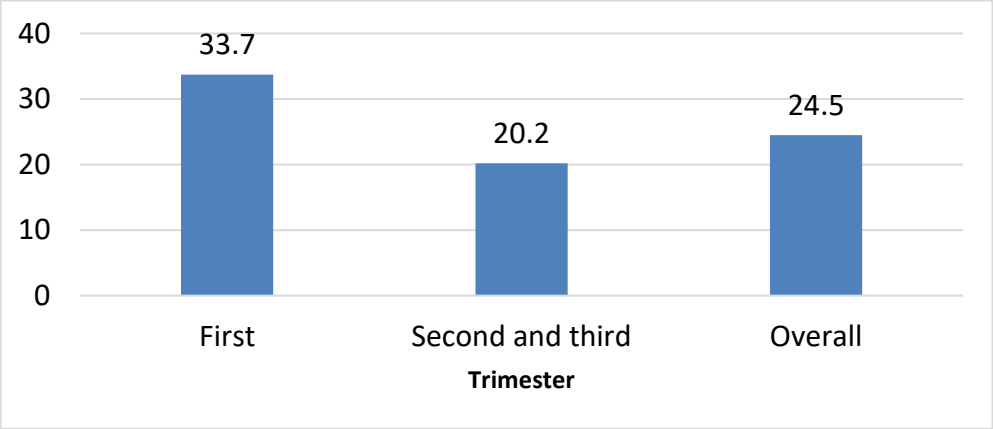
Table 7.5: Prevalence of VDD by sector

Sector	VDD	N
Urban	40.4	47
Rural	31.8	236
Estate	55.9	34
Sri Lanka	**35.6**	**317**

7.7 Zinc deficiency

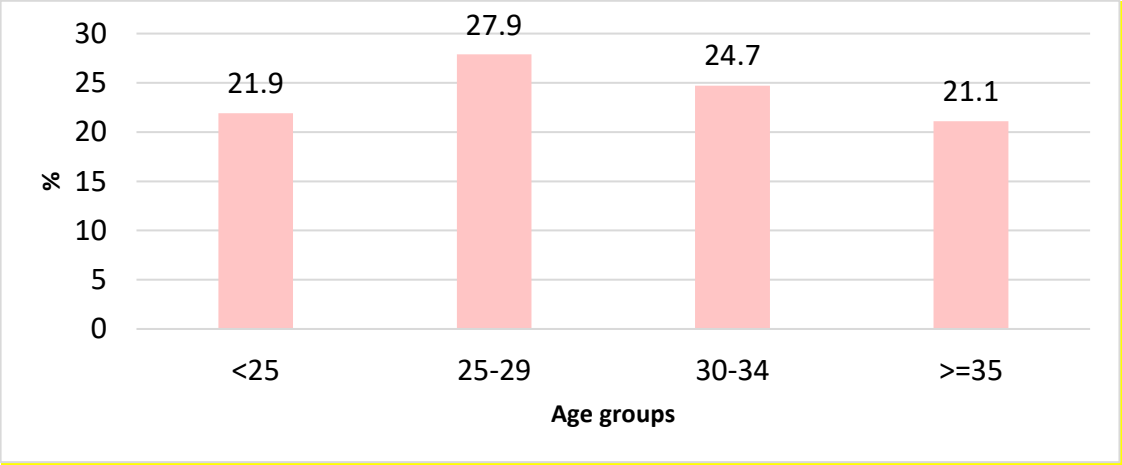
Serum zinc levels of 314 pregnant women were assessed. Mean zinc level was 85.6±37.8 µg/dL. Cut-off points for morning and afternoon were used separately to categorize zinc deficiency.

Figure 7.12: Prevalence of zinc deficiency in pregnant women by trimester



The prevalence of zinc deficiency among pregnant women was 24.5% (Figure 7.12). The prevalence of zinc deficiency during the first trimetser was 33.7%.

Figure 7.13: Prevalence of zinc deficiency by age



The prevalence of pregnant women with zinc deficiency was higher in the 25-29 years age category. There is no consistent pattern of zinc deficiency with increasing age (Figure 7.13).

Highest prevalence of zinc deficiency was observed in pregnant women residing in urban sector (28.3%) (Table 7.6)

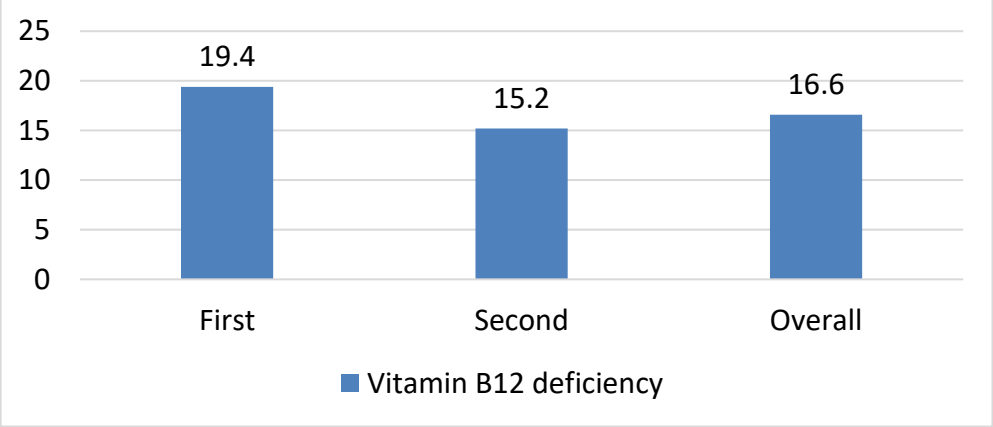
Table 7.6: Prevalence of Zinc deficiency by sector

Sector	%	N
Urban	28.3	46
Rural	24.3	235
Estate	21.2	33
Sri Lanka	**24.5**	**314**

7.8 Vitamin B_{12} deficiency

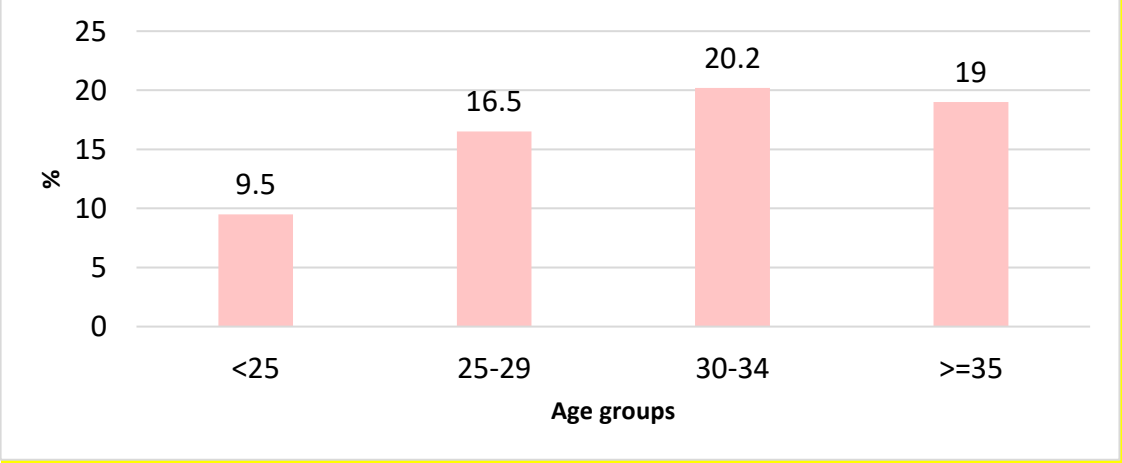
Serum vitamin B_{12} levels of 313 pregnant women were assessed. Mean vitamin B_{12} level was 242.3±105.1 pg/mL. Cut-off points for Vitamin B_{12} deficiency were taken at <150 pg/mL.

Figure 7.14: Prevalence of Vitamin B_{12} deficiency in pregnant women by trimester



The prevalence of vitamin B_{12} deficiency among pregnant women was 16.6% (Figure 7.14). The prevalence of vitamin B_{12} deficiency during the first trimetser was 19.4%.

Figure 7.15: Prevalence of Vitamin B_{12} deficiency by age



The prevalence of pregnant women with Vitamin B_{12} deficiency was higher in the 30-34 years age category. There is an increasing trend with increasing age (Figure 7.15).

Highest prevalence of vitamin B_{12} deficiency was observed in rural sector (18.5%) (Table 7.7)

Table 7.7: Prevalence of Vitamin B_{12} deficiency by sector

Sector	Vitamin B12 deficiency	N
Urban	6.5	46
Rural	18.5	233
Estate	17.6	34
Sri Lanka	**16.6**	**313**

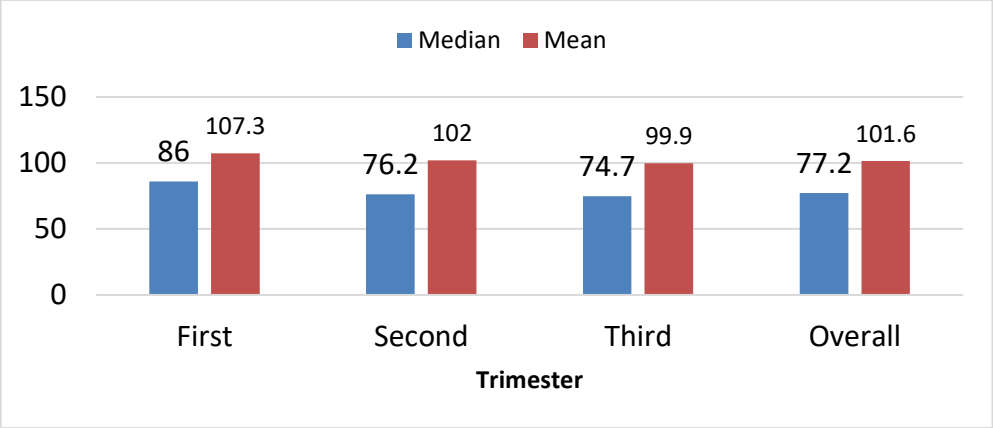
7.9 Causes of anaemia

Overall prevalence of anaemia among pregnant women aged 16-48 years were 15.0%, out of them 15.0% had iron deficiency, 35.1% had vitamin D deficiency, 33.3% had zinc deficiency, 18.9% had vitamin B_{12} deficiency and 3.7% had acute inflammation. Other causes such as folic acid deficiency, thalassemia and chronic inflammation should be explored.

7.10 Iodine deficiency

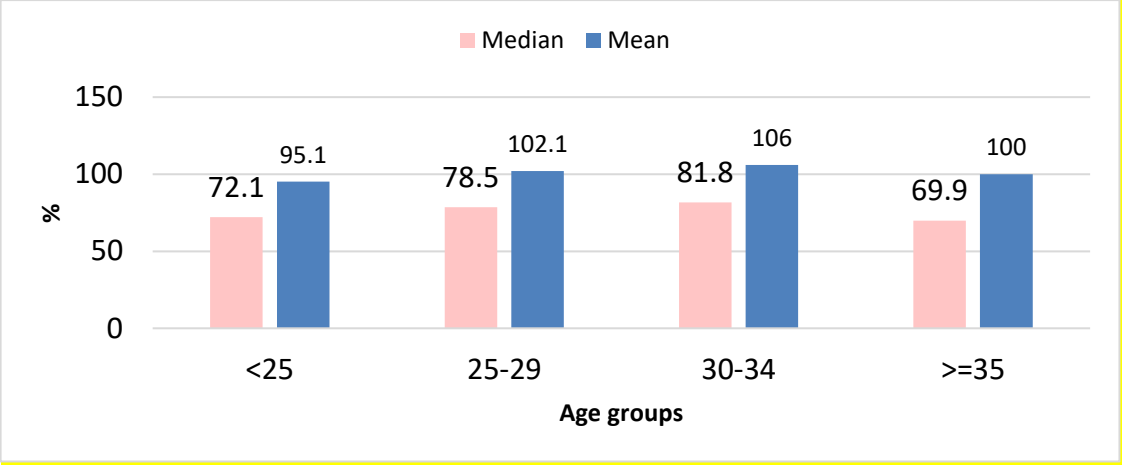
Urine iodine levels of 895 pregnant women were assessed. Median iodine level was 77.2 µg/L (25^{th} percentile-75^{th} percentile:38.8-141.8). Cut-off points for iodine deficiency was 150 µg/L.

Figure 7.16: Median iodine levels in pregnant women by trimester



The median urinary iodine level among pregnant women was decresing with increasin trimester. (Figure 7.16). Overall median iodine levels were below the optimum level in all trimesters.

Figure 7.17: Median iodine levels in pregnant women by age



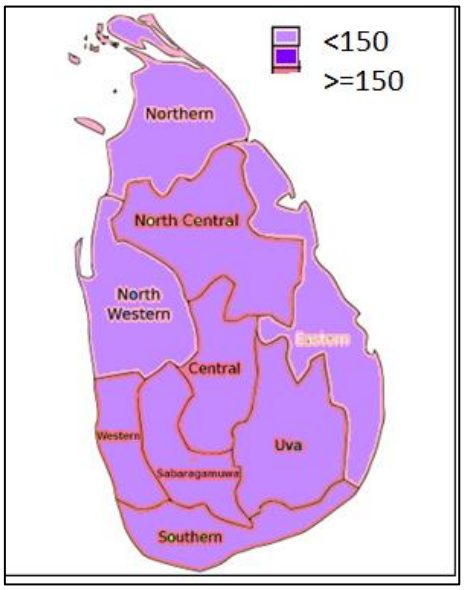
Median iodine level of pregnant women was lowest in pregnant women aged 35 years. There is an increasing median iodine level with increasing age (Figure 7.17). However, in all age groups median iodine levels were below the optimum level of 150 µg/L.

Inter provincial comparisons show the median iodine levels range between a low value of 46.5 µg/L in Sabaragamuwa province to 106.1 µg/L in Northern province (Table 7.8). All 9 provinces and overall, Sri Lanka median iodine levels were lower than the optimum level of 150 µg/L. Lowest median iodine levels were observed in Estate sector (43.3 µg/L).

Table 7.8: Median and mean iodine levels of pregnant women by province and sector

Province	Median iodine level (µg/L)	Mean iodine level (µg/L)	N
Western	65.2	91.6	143
Central	66.5	95.6	107
Southern	103.0	120.6	133
Northern	106.1	135.9	95
Eastern	64.8	92.7	113
Northwestern	87.1	108.1	96
Northcentral	66.6	99.3	59
Uva	76.1	84.8	79
Sabaragamuwa	46.5	75.3	70
Sector			
Urban	65.1	87.1	139
Rural	82.7	108.9	683
Estate	43.3	61.8	73
Sri Lanka	**77.2**	**101.6**	**895**

Figure 7.18: Provincial map of Sri Lanka according to median iodine level



According to the median iodine values, all 9 provinces have not reached to optimum level of iodine (Figure 7.18 and Table 7.6).

7.11 Supplements

Table 7.9 shows 68.0% has received preconceptual folic acid and 92.3% received supplements (iron, folate) from the ANC. Overall 96.8% pregnant women had received iron supplements.

Table 7.9: Percentage of pregnant women received supplements

Characteristics	%
Received preconceptual folic acid	68.0
Duration of receiving folic acid	
< one month	13.8
1-3 months	39.1
> 3 months	47.1
Received other supplements from ANC	92.3
Mean (SD) POA of receiving supplements in weeks	11.4 (3.0)
Place of receiving supplements	
Hospital	3.9
Field clinic	76.7
Private	19.1
Other	0.3
Mean (SD) months of not receiving supplements	2.4 (1.7)
Took from elsewhere when not received supplements from ANC (n=96)	75.0
Place of obtaining supplements when it is not received (n=96)	
Pharmacy	96.8
Hospital	3.2
Informed mother is anaemic during booking visits	
Yes	12.7
No	85.0
Don’t know	
Type of supplements received from ANC	
Iron/folate combined tablet	33.1
Iron only	63.7
Folic acid only	47.7
Vitamin C only	69.9
Calcium	74.3
Other	13.1
Received Thriposha	31.7
Had fever during this pregnancy	7.8
Had any other illness during this pregnancy	8.8
Had COVID-19 infection	9.0
Had COVID-19 vaccine	
1st dose only	4.3
1st and 2nd doses	6.6
1st, 2nd, and 3rd doses	45.8
All 4th doses	43.3

CHAPTER 8: ADULT WOMEN AGED 18-60 YEARS

8.1 Nutrition status

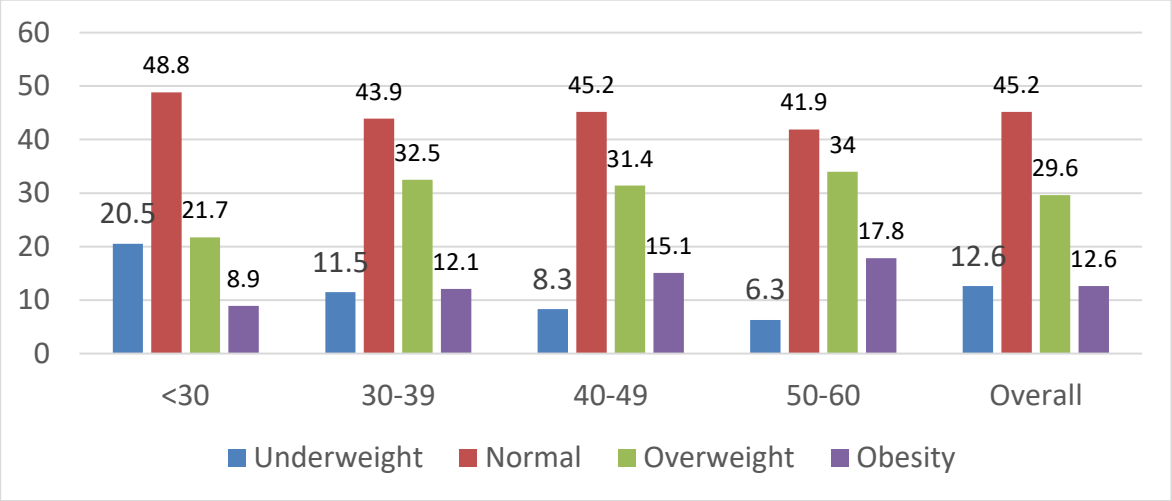
Table 8.1 shows the age distribution of the pregnant women included for anthropometry (weight and height).

Table 8.1: Age distribution of women aged 18-60 years.

AGE (years)	no.	%
< 30	414	26.5
30-39	643	41.2
40-49	312	20.0
50-59	191	12.2
Total	**1560**	**100.0**

As seen in Figure 8.1, 45% of women are within normal BMI (18.5-24.9 kg/m^2). Around 12.6% of women are underweight, 29.6% were overweight and 12.6% were obese. The highest prevalnce of overweight and obesity was obsrved among women aged 50-60 years of age. The highest prevalence of underweight was observed among women below 30 years of age.

Figure 8.1: Underweight, overweight and obesity of women aged 18-60 years by age



Inter provincial comparisons show the underweight prevalence to range between a low value of 7.5% in Northern province to18.9% in Central province (Table 8.2). Overweight prevalence ranges between a low value of 24.9% in Central province to 34.1% in Northcentral province. Obesity prevalence ranges between a low value of 8.6% in Southern province to 17.2% in Western province. The highest prevalence of underweight is found in estate sector (22.8%), overweight (33.0%) and obesity (24.5%) in urban sector.

Table 8.2: Prevalence of underweight, overweight and obesity by province and sector

	Underweight	Normal	Overweight	Obesity	N
Province					
Western	13.2	38.9	30.7	17.2	303
Central	18.9	45.5	24.9	10.7	233
Southern	12.3	47.1	32.1	8.6	187
Northern	7.5	47.5	31.7	13.3	120
Eastern	9.3	44.3	32.9	13.6	140
Northwestern	11.1	48.9	29.6	10.4	135
Northcentral	11.6	40.3	34.1	14.0	129
Uva	13.8	48.5	27.7	10.0	130
Sabaragamuwa	10.9	50.8	25.7	12.6	183
Sector					
Urban	11.5	31.0	33.0	24.5	200
Rural	11.6	47.2	30.1	11.2	1211
Estate	22.8	48.3	21.5	7.4	149
Sri Lanka	**12.6**	**45.2**	**29.6**	**12.6**	**1560**

8.2 Anaemia

The haemoglobin (Hb) levels of 1518 women were assessed using the Erba elite 3-part hematology analyser with venous blood. Mean Hb was 12.9±1.3 g/dL. The cutoff point - Hb <12.0 gms/dL and adjusted for altitudes was used to define anaemia. Mild, moderate, and severe anaemia was defined as Hb 11.0-11.9 g/dL, 8.0-10.9 g/dL and <8g/dL respectively.

The prevalence of overall anaemia, mild, moderate and severe anaemia among women was 18.5%, 12.3%, 5.7% and 0.5% respectively (Figure 8.2).

Figure 8.2: Prevalence of anaemia in women

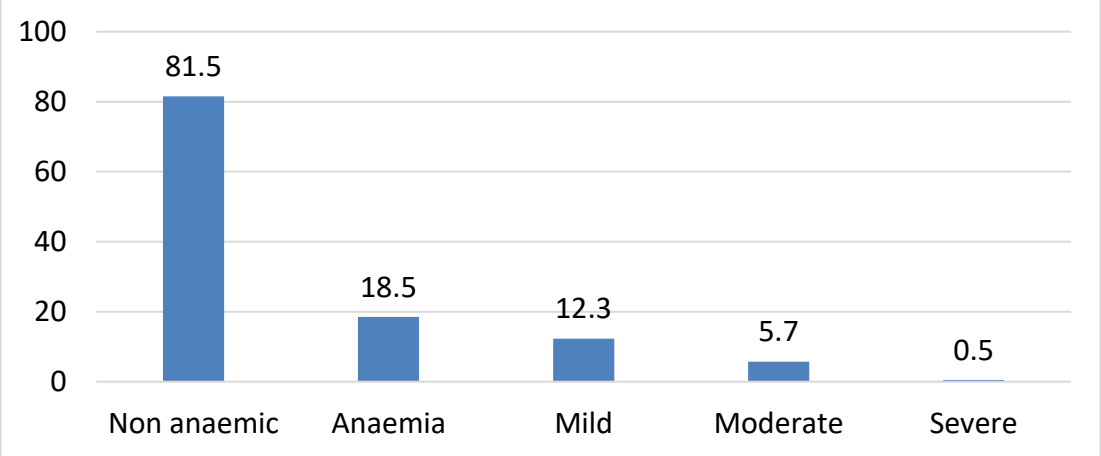
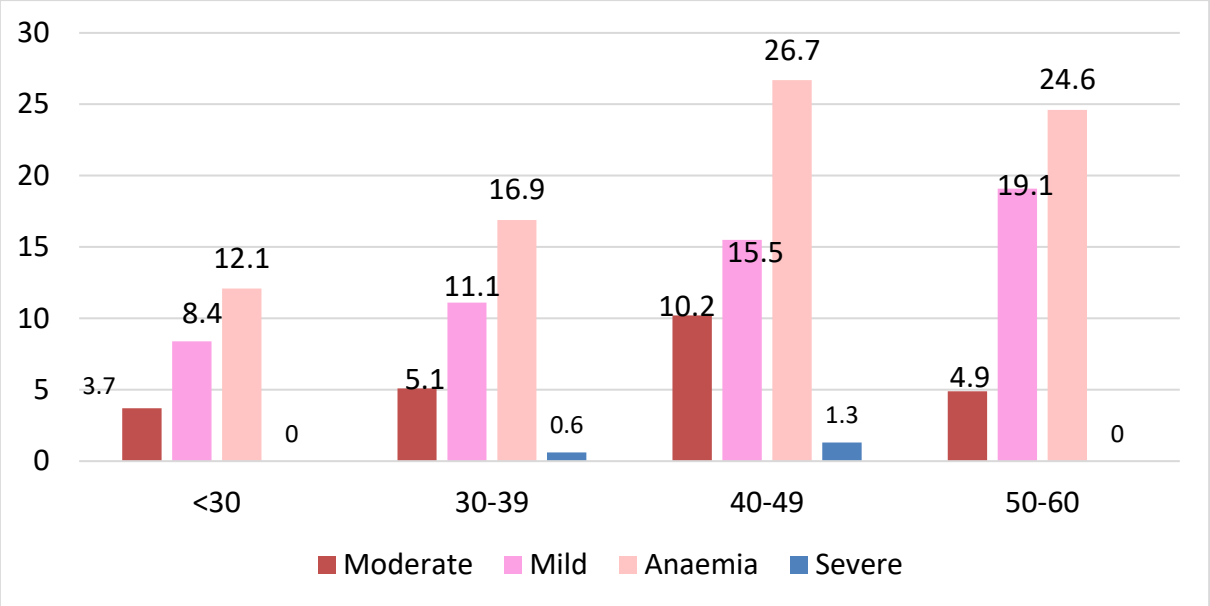


Figure 8.3: Prevalence of anaemia by age



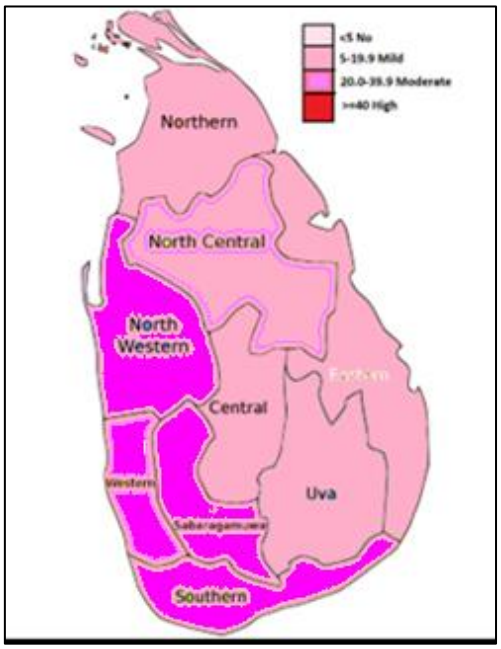
The prevalence of overall anaemia, moderate, and severe anaemia was higher in the 40-49 years of age categories. There is an increasing trend of mild anaemia with increasing age up to 40-49 years from 12.1% to 26.7% (Figure 8.3).

Table 8.3: Prevalence of anaemia by province and sector

	Severe anaemia	Moderate anaemia	Mild anaemia	Overall anaemia	Non anaemic	N
Province						
Western	1.0	5.8	15.0	21.8	78.2	294
Central	0.0	3.9	8.5	12.9	87.1	224
Southern	0.0	6.5	15.7	22.2	77.8	185
Northern	0.9	6.0	12.2	18.3	81.7	115
Eastern	0.0	2.9	8.0	10.9	89.1	137
Northwestern	0.0	4.6	18.6	24.0	76.0	129
Northcentral	0.8	6.3	11.8	18.1	81.9	127
Uva	0.8	7.0	3.9	11.8	88.2	127
Sabaragamuwa	1.1	8.9	13.9	23.3	76.7	180
Sector						
Urban	0.5	4.6	14.3	19.4	80.6	196
Rural	0.4	6.0	12.3	18.9	81.1	1175
Estate	1.4	4.8	8.8	14.3	85.7	147
Sri Lanka	**0.5**	**5.7**	**12.3**	**18.5**	**81.5**	**1518**

Inter provincial comparisons show the anaemia prevalence to range between a low value of 10.9% in Eastern province to 24.0% in Northwestern province (Table 8.3). Among 9 provinces that have prevalence above the average for national level were Western, Southern, Northern, Northwestern, Northcentral and Sabaragamuwa provinces. The other provinces reported prevalence figures lower than that for national level. The highest prevalence of anaemia is found in urban sector (19.4%).

Figure 8.4: Provincial map of Sri Lanka according to severity of anaemia

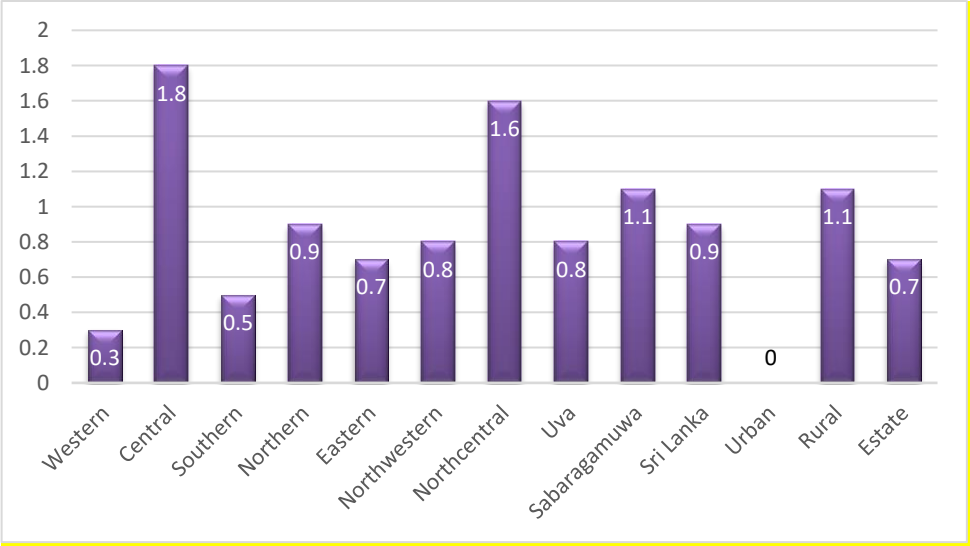


According to the prevalence values that identify anaemia as a problem of public health significance as specified by the WHO, the findings of this study shows that anaemia is of public health significance at a 'moderate' level, in Western, Southern, Northwestern and Sabaragamuwa provinces (Figure 8.4).

8.3 Acute inflammation

Acute Reactive Phase (CRP) levels were determined to identify acute infections. When the CRP level was higher than 5 mg/L, it was defined as a presence of acute inflammation. In the study sample, 0.9% of women had acute inflammation and varied from 0.3% in Western province to 1.8% in Central province (Figure 8.5).

Figure 8.5: Prevalence of acute inflammation in different province (n=1518)



8.4 Iron deficiency

Serum ferritin values of 1494 women are assessed. Mean ferritin level was 68.4±60.8 µg/L. The cutoff point of ferritin <15.0 µg/L when CRP is<6 mg/L and ferritin <70.0 µg/L when CRP is >5 mg/L was used to define iron deficiency (ID).

The prevalence of ID among women was 7.2% and highest among women aged 40-49 years age group (Figure 8.6).

Figure 8.6: Prevalence of iron deficiency (ID) in women by age

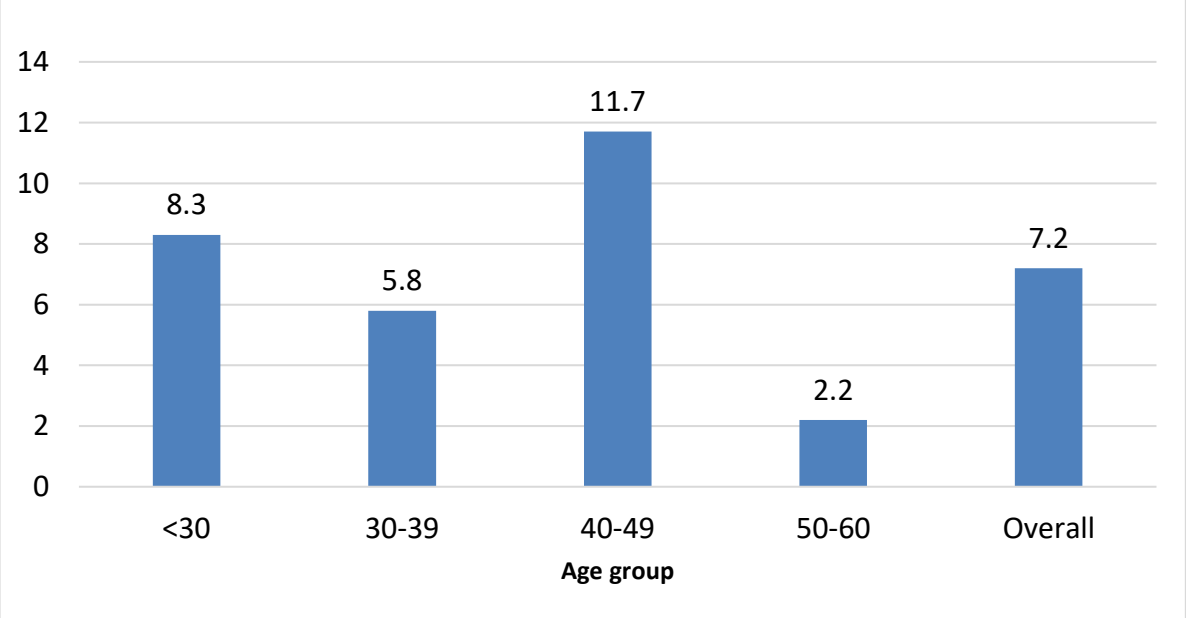
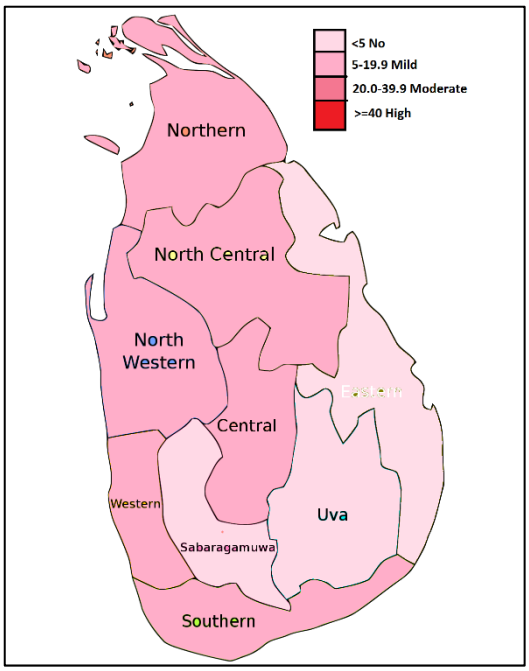


Table 8.4: Prevalence of iron deficiency by province and sector

Province	ID	N
Western	8.6	290
Central	8.2	219
Southern	5.4	184
Northern	10.4	115
Eastern	3.7	134
Northwestern	7.1	126
Northcentral	12.8	125
Uva	4.1	123
Sabaragamuwa	4.5	178
Sector		
Urban	5.6	195
Rural	7.0	1153
Estate	11.0	146
Sri Lanka	**7.2**	**1494**

Inter provincial comparisons show the prevalence to range between a low value of 4.1% in Uva province to 12.8% in Northcentral province (Table 8.4). Among 9 provinces that have prevalence higher the average for national level were Western, Central, Northern and Northcentral provinces. The other provinces reported prevalence figures lower than that for national level.

Figure 8.7: Provincial map of Sri Lanka according to severity of iron deficiency



According to the prevalence values that identify ID as a problem of public health significance as specified by the WHO, the findings of this study shows that ID is of public health significance at a 'mild' level, in overall Sri Lanka and in all 6 out of 9 provinces. However, ID is not a public health issue in Eastern, Uva and Sabaragamuwa provinces (Figure 8.7).

8.5 Iron deficiency anaemia

Table 8.5: Prevalence of iron deficiency anaemia (IDA) by age, sector, and provinces

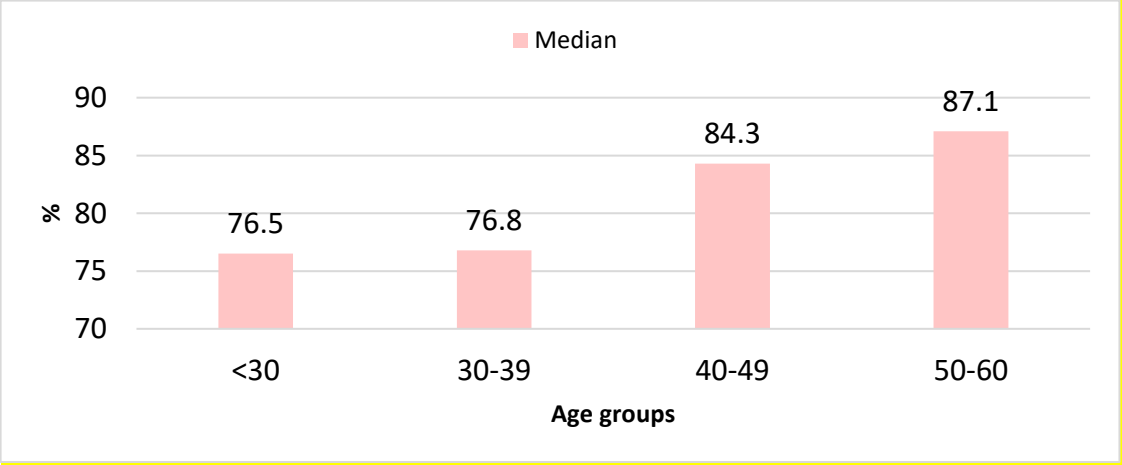
Background characteristic	No	% of women with IDA
Age in years		
< 30	397	2.3
30-39	617	2.4
40-49	299	7.4
50-60	181	1.1
Sector		
Urban	195	2.1
Rural	1153	3.0
Estate	146	6.2
Province		
Western	290	5.2
Central	219	4.1
Southern	184	1.6
Northern	115	6.1
Eastern	134	2.2
Northwestern	125	3.2
Northcentral	123	1.6
Uva	123	1.6
Sabaragamuwa	178	1.7
Sri Lanka	**1494**	**3.2**

Iron deficiency anaemia (IDA) was defined as presence of both anaemia and iron deficiency. Highest prevalence of IDA was seen among the women aged 40-49 years, living in estate sector, and residing in Northern province (Table 8.5).

8.6 Iodine deficiency

Urine iodine levels of 861 women were assessed. Median iodine level was 78.1 µg/L (25th percentile-75th percentile: 41.8-133.4). Cut-off points for iodine deficiency was 100 µg/L.

Figure 8.8: Median iodine levels in women by age



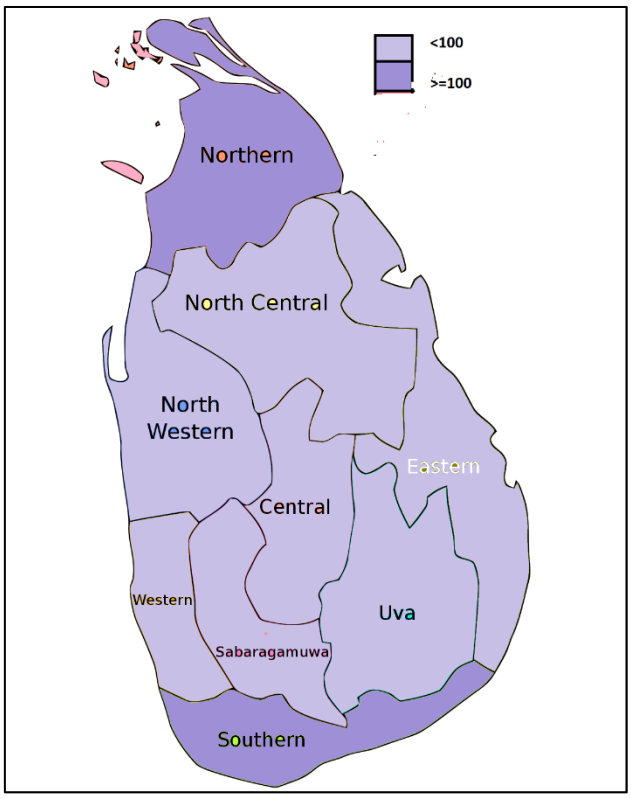
Median iodine level of women was increasing with the increasing age (76.5 – 87.1 µg/L).

Inter provincial comparisons show the median iodine levels range between a low value of 76.0 µg/L in Eastern province to 114.9 µg/L in Northern province (Table 8.6). All 9 provinces except in Southern and Northern provinces and overall, Sri Lanka median iodine levels were lower than the optimum level of 100 µg/L. Lowest median iodine levels was observed in estate sector (78.6 µg/L).

Table 8.6: Median iodine levels of women by province

Province	Median iodine level (µg/L)	Mean iodine level (µg/L)	N
Western	69.3	86.4	157
Central	74.8	98.0	95
Southern	111.9	120.8	103
Northern	114.9	137.3	81
Eastern	58.8	76.0	88
Northwestern	88.5	105.5	78
Northcentral	93.2	98.4	75
Uva	74.5	78.9	93
Sabaragamuwa	65.8	88.8	91
Sector			
Urban	60.7	83.1	98
Rural	81.1	100.7	726
Estate	66.2	78.6	37
Sri Lanka	**78.1**	**97.7**	**861**

Figure 8.9: Provincial map of Sri Lanka according to median iodine level



According to the median iodine values, all 9 provinces have not reached to optimum level of iodine except in Southern and Northern provinces (Figure 8.9).

CHAPTER 9: ADULT MALE AGED 18-60 YEARS OF AGE

9.1 Nutrition status

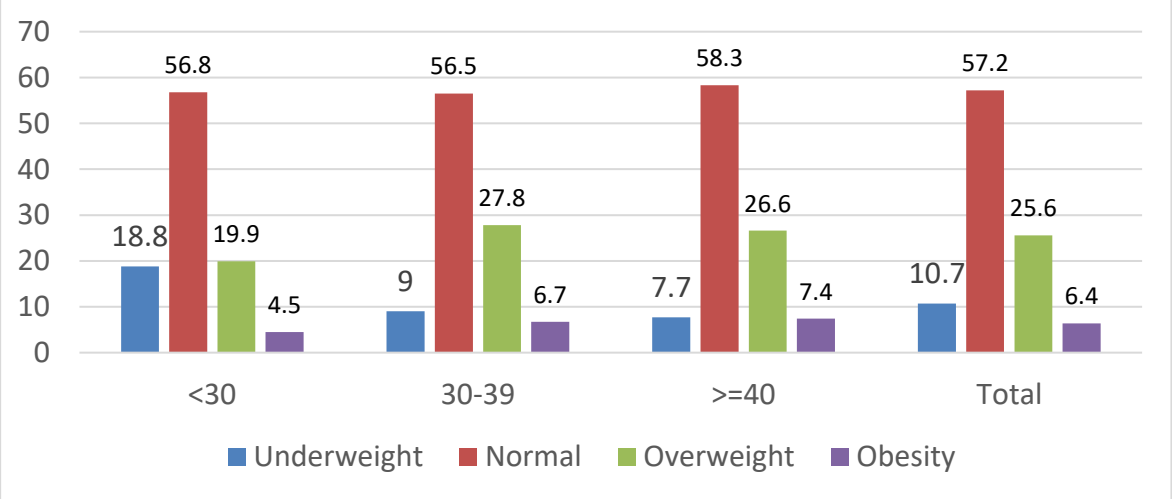
Table 9.1 shows the age distribution of the men included for anthropometry (weight and height).

Table 9.1: Age distribution of men

AGE (years)	no.	%
< 30	176	22.2
30-39	345	43.6
≥40	271	34.2
Total	**792**	**100.0**

As seen in Figure 9.1, almost half of men are within normal BMI. Around 11% of men are underweight, 25.6% were overweight and 6.4% were obese. There is an increasing trend of obesity with increasing age. Underweight was highest among men below 30 years of age.

Figure 9.1: Underweight, overweight and obesity of men by age (n=792)



Inter provincial comparisons show the underweight prevalence to range between a low value of 1.5% in Eastern province to18.4% in Sabaragamuwa province (Table 9.2). Overweight prevalence ranges between a low value of 14.4% in Central province to 36.1% in Northcentral province. Obesity prevalence ranges between a low value of 0.0% in the study sample in Uva province to 13.4% in Northern province. The highest prevalence of underweight is found in the estate sector (18.8%); overweight (35.6%) and obesity (12.7%) in urban sector.

Table 9.2: Prevalence of underweight, overweight and obesity by province and sector

	Underweight	Normal	Overweight	Obesity	N
Province					
Western	12.5	45.4	33.6	8.6	152
Central	12.5	68.3	14.4	4.8	104
Southern	15.7	50.0	30.6	3.7	108
Northern	3.0	55.2	28.4	13.4	67
Eastern	1.5	68.7	20.9	9.0	67
Northwestern	10.9	57.8	23.4	7.8	64
Northcentral	5.6	50.0	36.1	8.3	72
Uva	8.5	69.0	22.5	0.0	71
Sabaragamuwa	18.4	62.1	16.1	3.4	87
Sector					
Urban	10.2	41.5	35.6	12.7	118
Rural	9.9	58.5	25.8	5.8	605
Estate	18.8	72.5	7.2	1.4	69
Sri Lanka	**10.7**	**57.2**	**25.6**	**6.4**	**792**

9.2 Anaemia

The haemoglobin (Hb) levels of 768 men were assessed using the Erba elite 3-part hematology analyser with venous blood. Mean Hb was 14.8±1.4 g/dL. The cutoff point - Hb <13.0 gms/dL and adjusted for altitudes was used to define anaemia. Mild, moderate, and severe anaemia was defined as Hb 11.0-12.9 g/dL, 8.0-10.9 g/dL and <8g/dL respectively.

The prevalence of overall anaemia, mild and moderate anaemia among men was 8.2%, 7.0% and 1.2% respectively (Figure 9.2).

Figure 9.2: Prevalence of anaemia in men

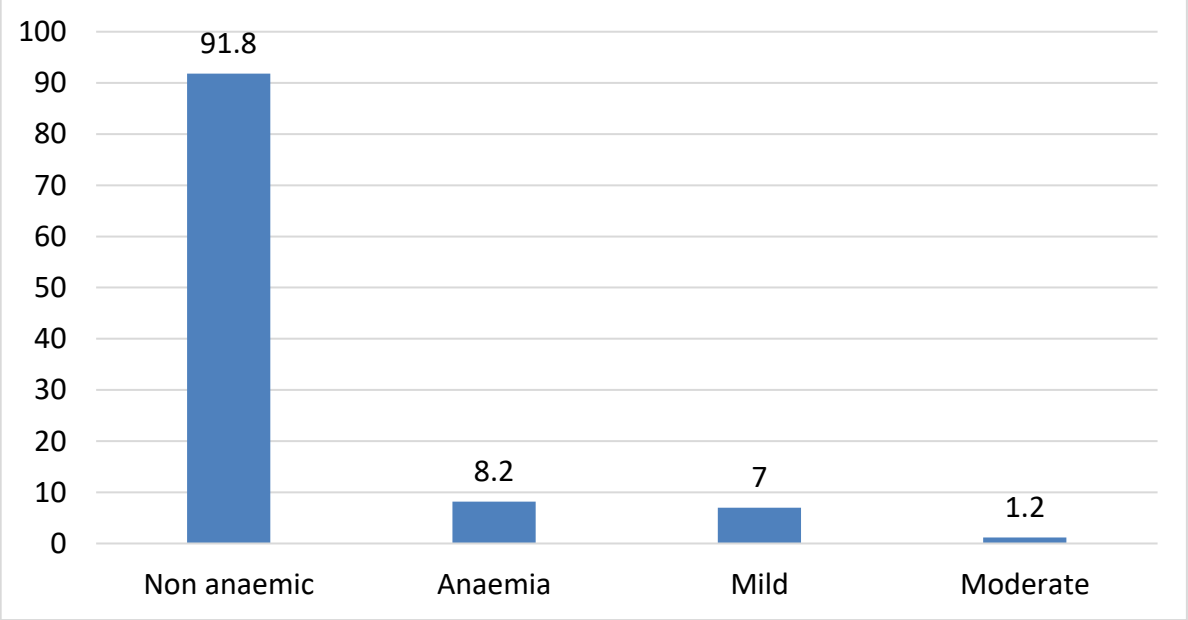
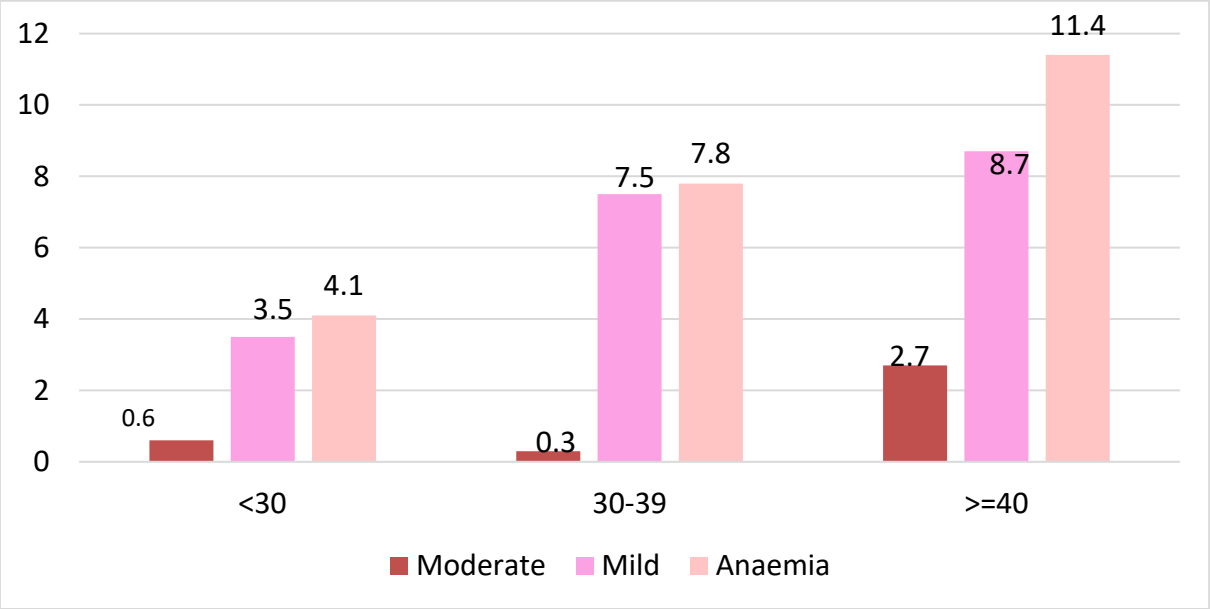


Figure 9.3: Prevalence of anaemia by age



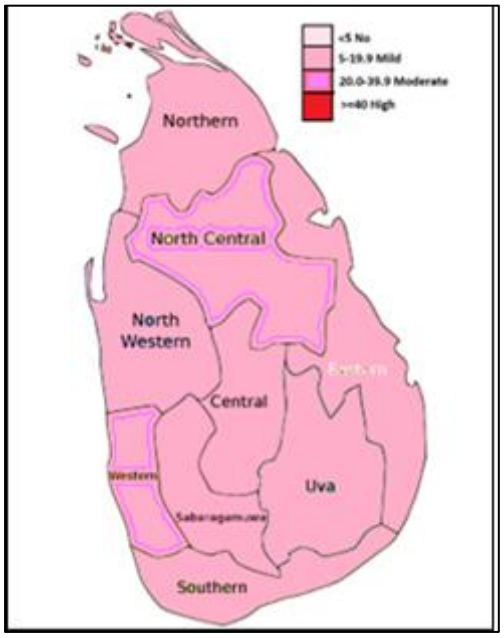
The prevalence of overall anaemia, moderate and mild anaemia was higher in the >=40 years age categories. There is an increasing trend of anaemia with increasing age from 4.1% to 11.4% (Figure 9.3).

Inter provincial comparisons show the prevalence to range between a low value of 2.8% in Southern province to 18.2% in Eastern province (Table 9.3). The highest prevalence of anaemia is found in rural sector (9.2%).

Table 9.3: Prevalence of anaemia by province and sector

	Moderate anaemia	Mild anaemia	Overall anaemia	Non anaemic	N
Province					
Western	0.7	6.2	6.8	93.2	146
Central	3.0	5.0	7.9	92.1	101
Southern	0.0	2.8	2.8	97.2	106
Northern	0.0	3.2	3.2	96.8	62
Eastern	4.5	13.6	18.2	81.8	66
Northwestern	0.0	8.1	8.1	91.9	62
Northcentral	0.0	10.1	10.1	89.9	69
Uva	0.0	2.9	2.9	97.1	70
Sabaragamuwa	2.3	14.0	16.3	83.7	86
Sector					
Urban	0.9	5.4	6.2	93.8	112
Rural	1.4	7.8	9.2	90.8	589
Estate	0.0	3.0	3.0	97.0	67
Sri Lanka	**1.2**	**7.0**	**8.2**	**91.8**	**768**

Figure 9.4: Provincial map of Sri Lanka according to severity of anaemia

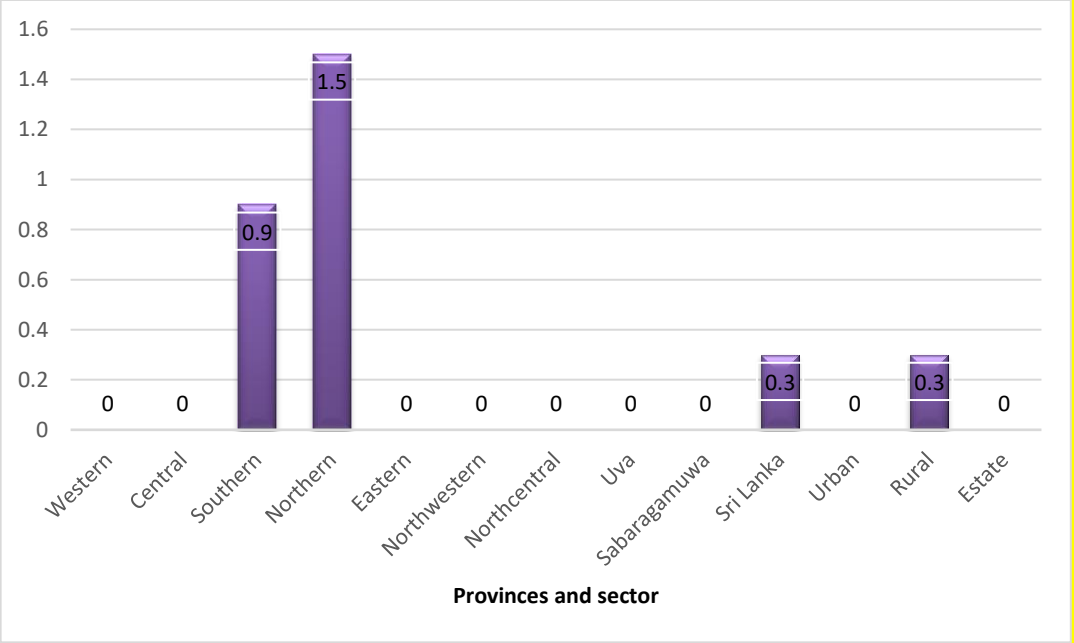


According to the prevalence values that identify anaemia as a problem of public health significance as specified by the WHO, the findings of this study shows that anaemia is of public health significance at a 'mild' level, in overall Sri Lanka and all provinces (Figure 9.4 and Table 9.3).

9.3 Acute inflammation

Acute Reactive Phase (CRP) levels were determined to identify acute infections. When the CRP level was higher than 5 mg/L, it was defined as a presence of acute inflammation. In the study sample, 0.3% of men had acute inflammation and varied from 0% in Western province to 1.5% in Northern province (Figure 9.5).

Figure 9.5: Prevalence of acute inflammation in different province

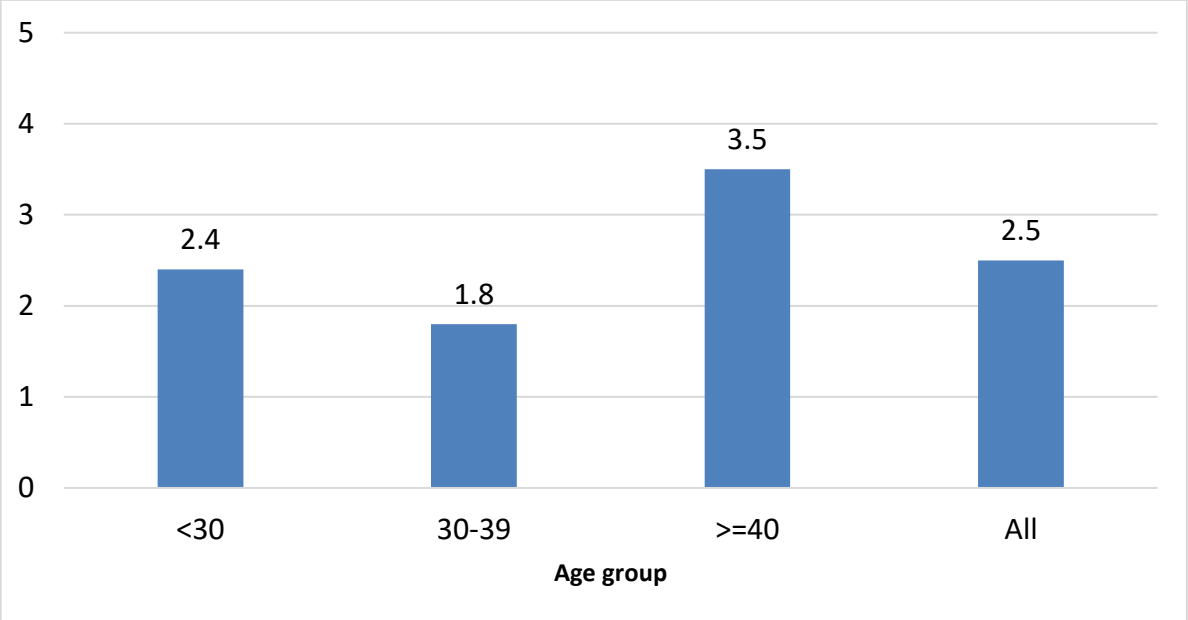


9.4 Iron deficiency

Serum ferritin values of 751 men are assessed. Mean ferritin level was 131.8±98.8 µg/L. The cutoff point of ferritin <15.0 µg/L when CRP is <6 mg/L and ferritin <70.0 µg/L when CRP is >5 mg/L was used to define iron deficiency (ID).

The prevalence of ID among men was 2.5% (Figure 9.6).

Figure 9.6: Prevalence of iron deficiency in men by age group



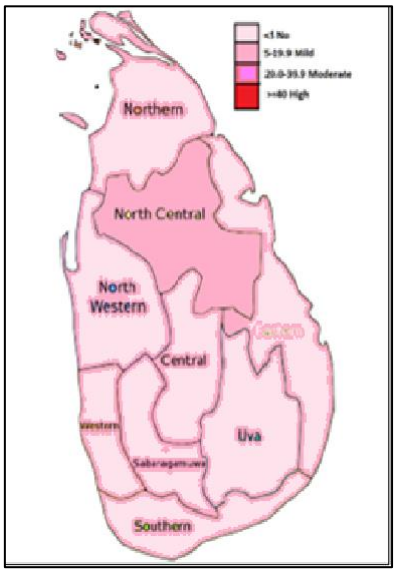
The prevalence of men with ID was higher in the >=40 years age category (Figure 9.7).

Table 9.4: Prevalence (%) of iron deficiency by province and sector

Province	ID	N
Western	2.1	144
Central	2.0	100
Southern	1.0	105
Northern	3.2	62
Eastern	1.5	65
Northwestern	1.6	61
Northcentral	6.2	65
Uva	1.5	67
Sabaragamuwa	4.7	85
Sector		
Urban	0.9	112
Rural	2.6	576
Estate	4.5	66
Sri Lanka	**2.5**	**754**

Inter provincial comparisons show the ID prevalence to range between a low value of 1.0% in Southern province to 6.2% in Northcentral province (Table 9.4). The highest prevalence of ID was observed in the estate sector (4.5%).

Figure 9.7: Provincial map of Sri Lanka according to severity of iron deficiency



According to the prevalence values that identify ID among men as a problem of public health significance as specified by the WHO, the findings of this study shows that ID is no more a public health significance in 8 out of 9 provinces in Sri Lanka (Figure 9.7 and Table 9.4).

9.5 Iron deficiency anaemia

Iron deficiency anaemia (IDA) was defined as presence of both anaemia and iron deficiency. Highest prevalence of IDA was seen among men less than 30 years, living in estate sector, residing in Eastern province (Table 9.5). Overall prevalence of ID was 0.4%.

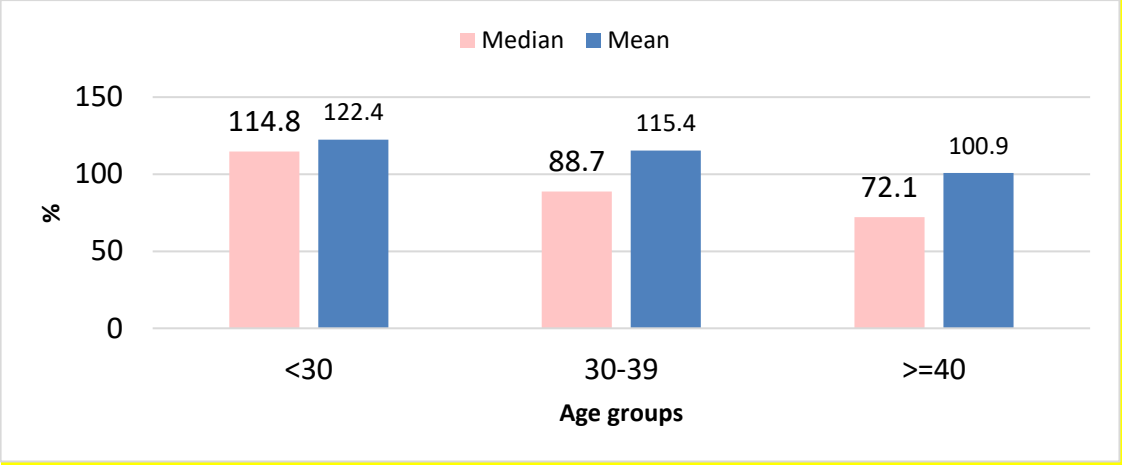
Table 9.5: Prevalence of iron deficiency anaemia (IDA) by age, sector, and provinces

Background characteristic	No	% of men with IDA
Age in years		
<30	167	0.6
30-39	326	0.3
≥ 40	258	0.4
Sector		
Urban	112	0.0
Rural	573	0.3
Estate	66	1.5
Province		
Western	144	0.0
Central	100	1.0
Southern	105	0.0
Northern	62	0.0
Eastern	65	1.5
Northwestern	61	0.0
Northcentral	65	0.0
Uva	67	0.0
Sabaragamuwa	85	1.2
Sri Lanka	**754**	**0.4**

9.6 Iodine deficiency

Urine iodine levels of 493 men were assessed. Median iodine level was 89.4 µg/L (25th percentile-75th percentile: 46.5 – 156.7). Cut-off points for iodine deficiency was 100 µg/L.

Figure 9.8: Median iodine levels in men by age



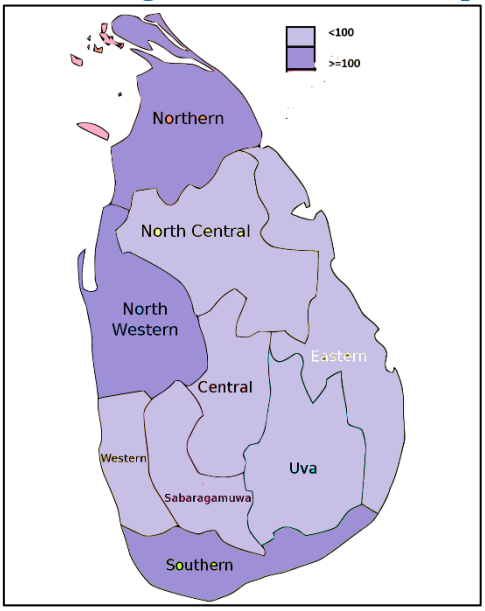
Median iodine level of men was decreasing with the increasing age (114.8 – 72.1 µg/L).

Inter provincial comparisons show the median iodine levels range between a low value of 65.0 µg/L in Western province to 152.0 µg/L in Southern province (Table 9.6). All 9 provinces and overall, Sri Lanka median iodine levels were lower than the optimum level of 100 µg/L. Lowest median iodine levels was observed in estate sector (60.0 µg/L).

Table 9.6: Median iodine levels of men by province and sector

Province	Median iodine level (µg/dL)	Mean iodine level (µg/dL)	N
Western	65.0	81.0	96
Central	76.5	101.6	53
Southern	152.0	152.0	57
Northern	143.4	161.3	49
Eastern	69.3	78.9	41
Northwestern	114.4	127.6	45
Northcentral	85.6	103.3	51
Uva	99.8	111.4	52
Sabaragamuwa	74.8	106.5	47
Sector			
Urban	73.4	86.0	70
Rural	99.0	117.2	393
Estate	60.0	96.4	28
Sri Lanka	**89.4**	**111.6**	**491**

Figure 9.9: Provincial map of Sri Lanka according to median iodine level



According to the median iodine values, all 6 out of 9 provinces have not reached to optimum level of iodine except in Southern, Northern and Northwestern provinces (Figure 9.9 and Table 9.6).

CHAPTER 10: ADULTS ABOVE 60 YEARS OF AGE

10.1 Nutrition status

Table 10.1 shows the age distribution of the adults>60 years population included for anthropometry (weight and height).

Table 10.1: Age distribution of adults > 60 years

AGE (years)	no.	%
60 - 69	256	67.2
≥ 70	125	32.8
Total	**381**	**100.0**

As seen in Figure 10.1, 12.1% of elderly are underweight, 27.3% were overweight and 7.1% were obese. BMI distribution of male and female were also provided.

Figure 10.1: Underweight, overweight and obesity of adults > 60 years by sex

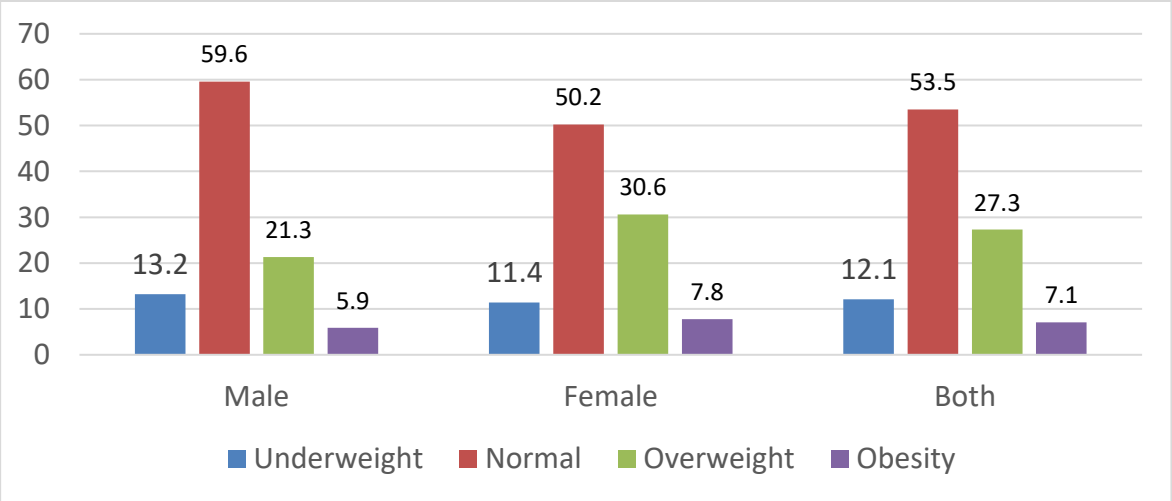


Figure 10.2 shows, underweight was higher among >=70 years group than 60-69 years age group (16% vs 10.2%).

Figure 10.2: Underweight, overweight and obesity of elderly by sex

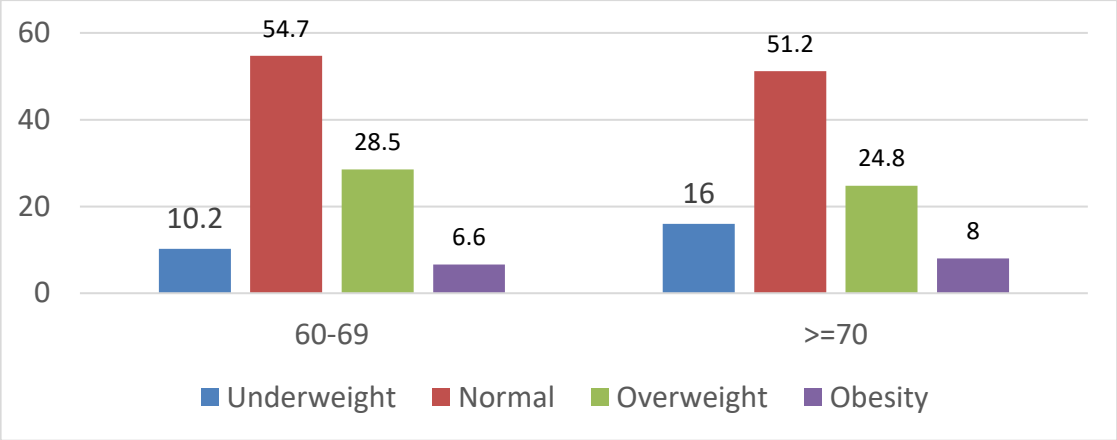


Table 10.2: Prevalence of underweight, overweight and obesity by sector

	Underweight	Normal	Overweight	Obesity	N
Sector					
Urban	19.0	45.2	26.2	9.5	42
Rural	11.4	54.1	27.5	7.0	316
Estate	8.7	60.9	26.1	4.3	23
Sri Lanka	**12.1**	**53.5**	**27.3**	**7.1**	**381**

Table 10.2 shows the highest percentage of underweight and obese elderly was observed in the urban sector.

10.2 Iodine deficiency

Urine iodine levels of 352 adults > 60 years were assessed. Median iodine level was 67.3 µg/L (25th percentile-75th percentile: 36.6 – 135.7). Cut-off points for iodine deficiency was 100 µg/L (Figure 10.3).

Figure 10.3: Median iodine levels in elderly by age

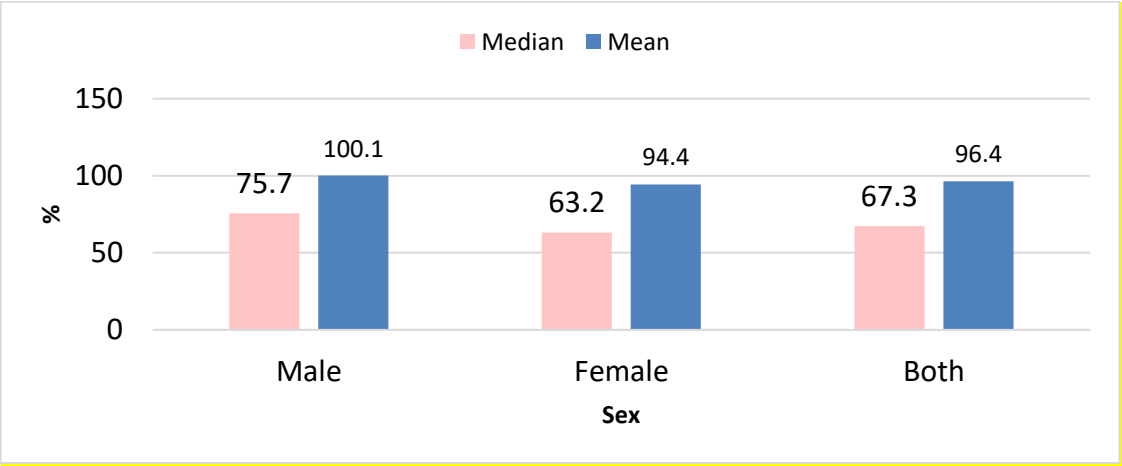
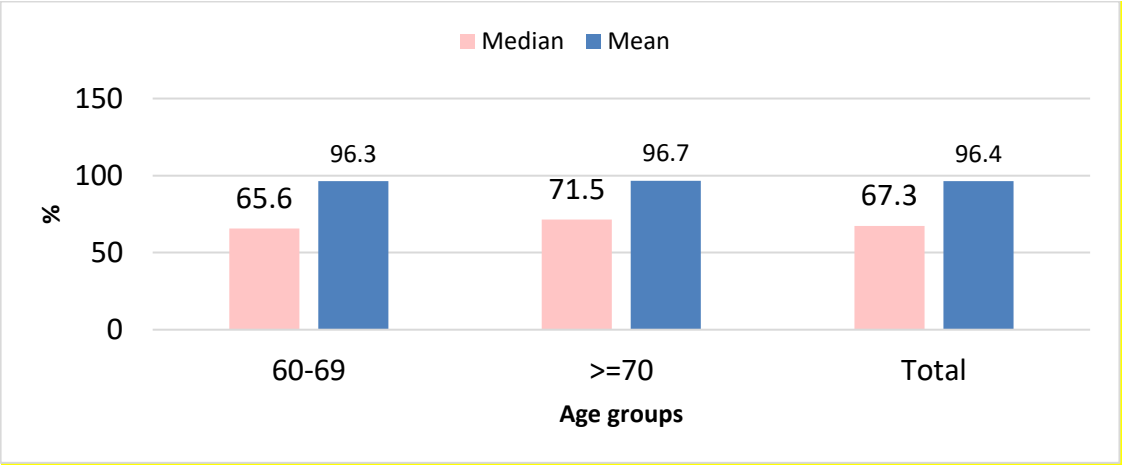


Figure 10.3 shows the sex distribution. Higher median iodine value was observed in female than male (75.7 vs 63.2 µg/L). Figure 10.4 shows the median iodine levels of two age groups.

Figure 10.4: Median iodine levels in elderly by age



Inter provincial comparisons show the median iodine levels range between a low value of 44.3 µg/dL in Sabaragamuwa province to 130.9 µg/L in Southern province (Table 10.3). All 9 provinces except Southern and Northern provinces and overall, Sri Lanka median iodine levels were lower than the optimum level of 100 µg/L. Lowest median iodine levels was observed in Estate sector (57.3 µg/L).

Table 10.3: Median iodine levels of elderly by province

Province	Median iodine level (µg/L)	Mean iodine level (µg/L)	N
Western	63.1	90.9	75
Central	63.1	86.9	50
Southern	130.9	142.1	47
Northern	113.4	138.1	14
Eastern	58.8	79.5	23
Northwestern	70.9	85.3	22
Northcentral	65.8	105.0	36
Uva	71.5	83.8	32
Sabaragamuwa	44.4	75.7	53
Sector			
Urban	58.6	80.6	34
Rural	71.2	98.8	296
Estate	57.3	90.2	22
Sri Lanka	**67.3**	**90.5**	**352**

CHAPTER 11: FOOD CONSUMPTION AND FOOD SECURITY AT HOUSEHOLD LEVEL

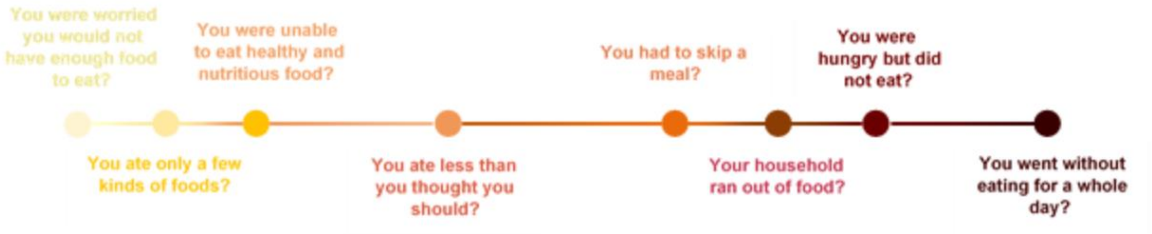
11.1 Food security

Two indicators of global Food Insecurity Experience Scale (FIES) explained by FAO in 2016 were used to determine the food security at household level.

• **FI-mod+sev** - The proportion of the population experiencing moderate or severe food insecurity (SDG indicator 2.1.2)

• **FI-sev** - The proportion of the population experiencing severe food insecurity

Global Food Insecurity Experience Scale (FIES) explained by FAO in 2016



Food insecurity severity along a continuous scale of severity

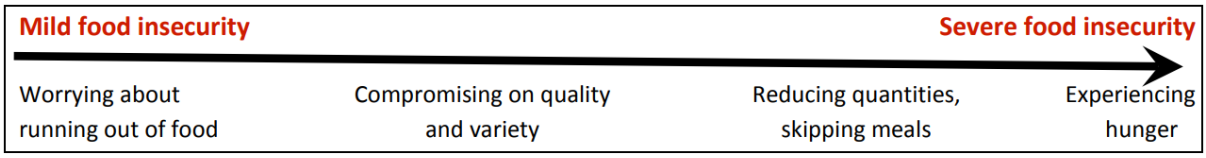


Figure 11.1: Prevalence of food insecurity by province

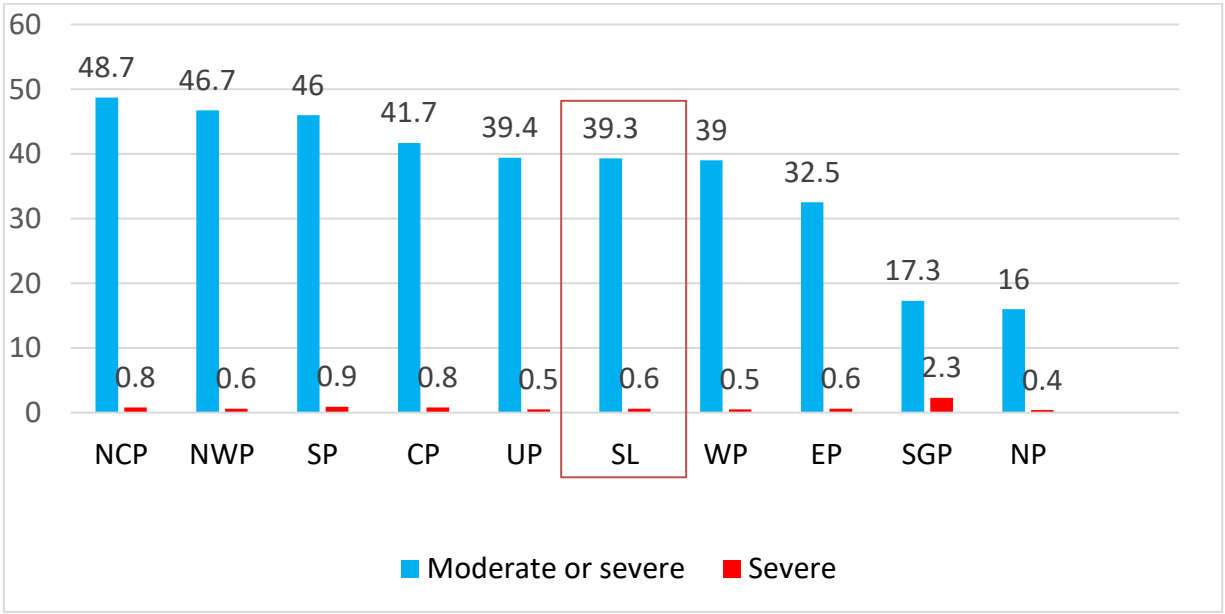
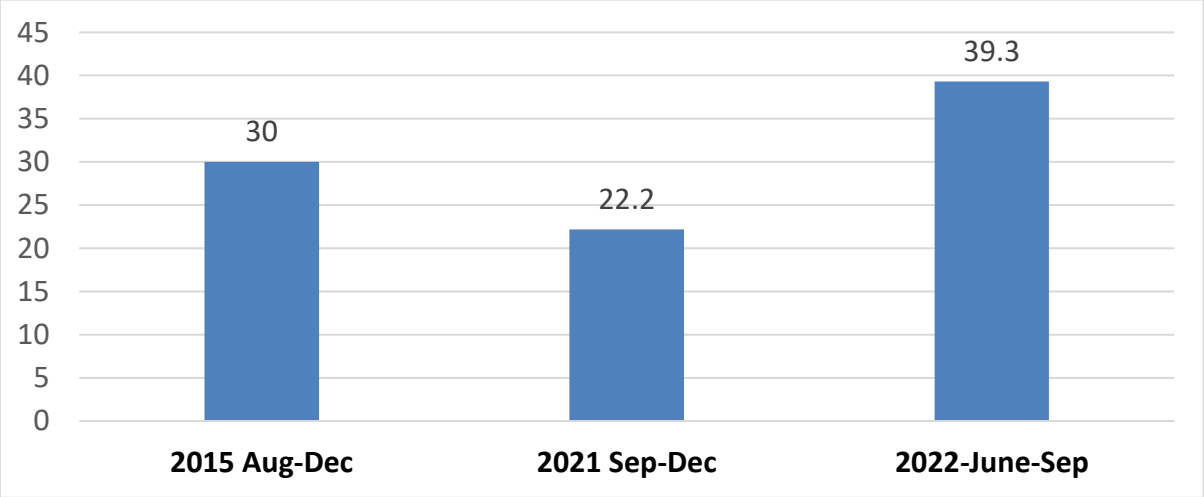


Figure 11.1 shows the highest prevalence of food insecurity in Northcentral province (48.7%) and the lowest in Northern province (16%). Overall, in Sri Lanka food insecurity at household level is 39.3%. Trends are provided in Figure 11.2.

Figure 11.2: Prevalence of food insecurity in compared with 2015, 2011 household data



11.2 Household food consumption

Household food consumption is important to identify households' dietary diversity, food frequency, and relative nutritional importance of different food groups. It is calculated by inspecting how often households consume food items from the different food groups during a 7-day reference period. Mean days of consumption of each food group is provided in Figure 11.3. The highest consumption was observed with cereal group and lowest from meat food group.

Figure 11.3: Mean household food consumption by food group and province

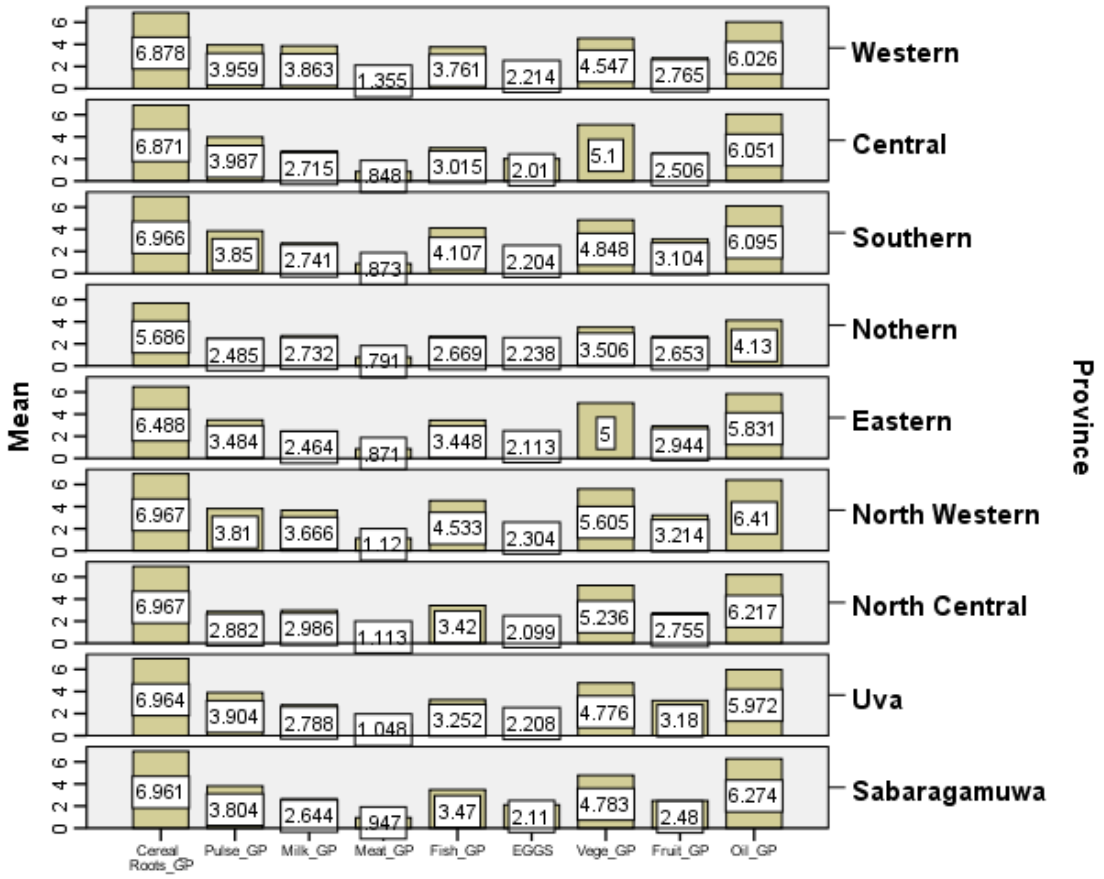


Figure 11.4: Mean consumption of biscuits and processed food by province

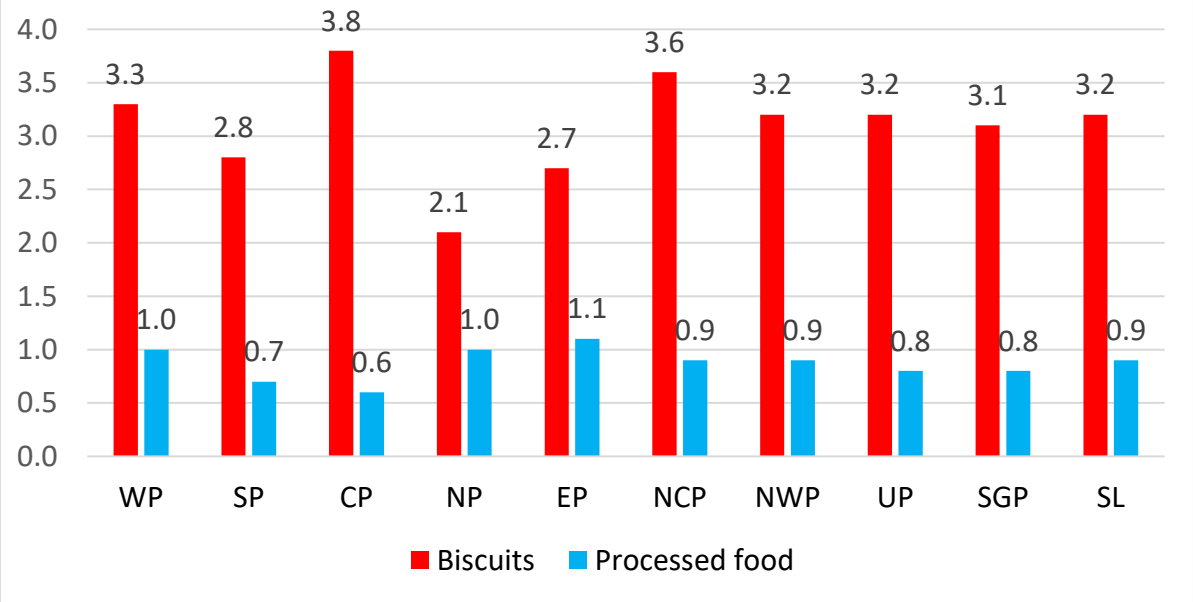
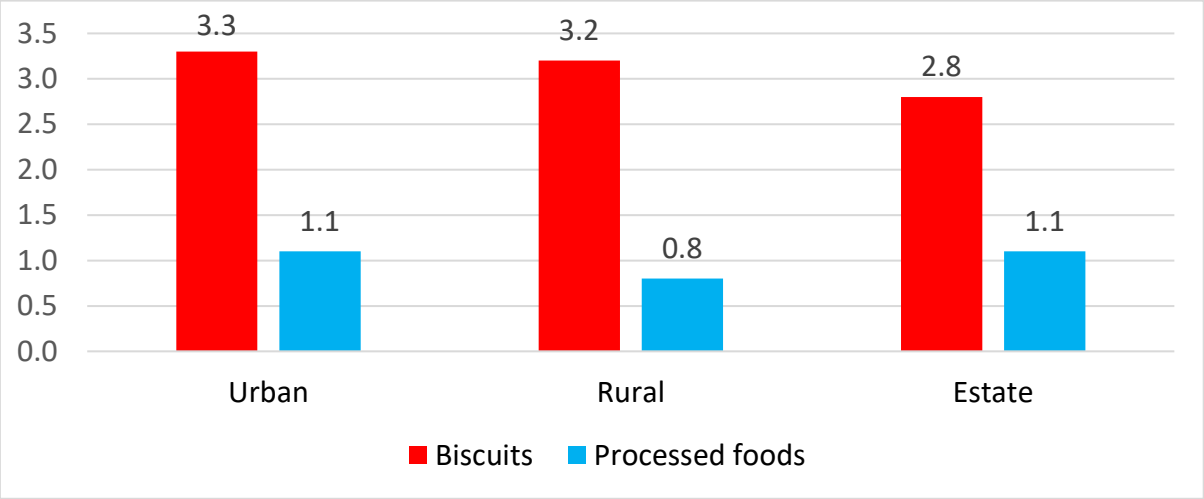


Figure 11.4 shows mean 3.2±2.5 and 0.9±0.3 days of biscuits and processed food consumption at household level respectively. Highest consumption of biscuits is observed in Central province and processed foods in Eastern province. Highest biscuits and processed foods consumption is observed in urban sector.

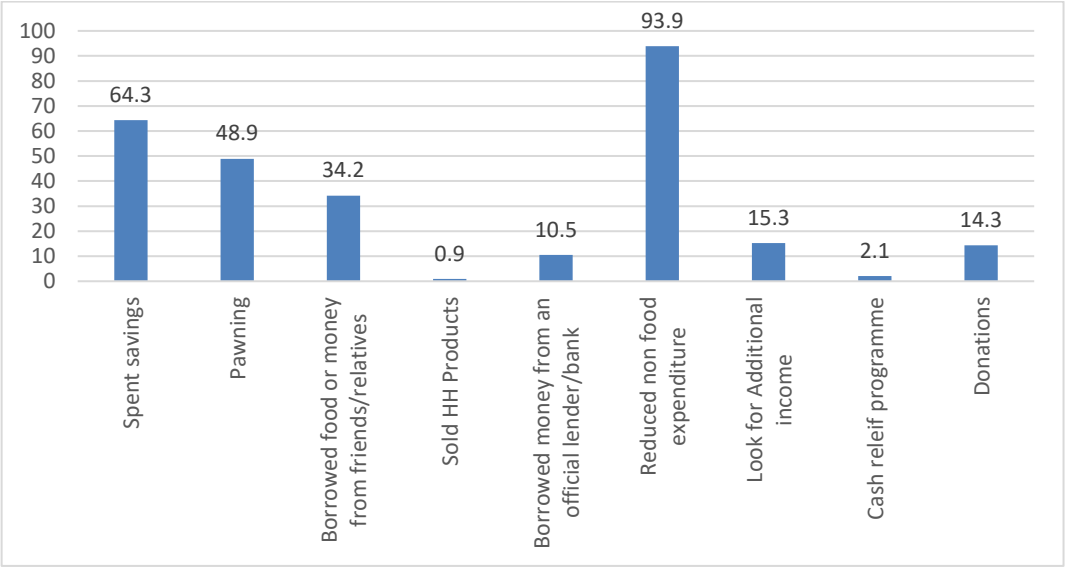
Figure 11.5: Mean consumption of biscuits and processed foods by sector



11.3 Livelihood coping strategies

Stress coping strategies include spent savings, borrowed food or money from friends/relatives and looking for additional income sources (e.g. temporary works). While crisis coping strategies are higher in severing and include strategies like selling of productive assets (radio, furniture etc.) and reducing essential non-food expenditure such as education and health. The most severe of all are the emergency coping strategies such as begging or engaging in risky income-generating activities.

Figure 11.6: Percentage households used livelihood coping strategies



During the 30 days before the survey, 93.9% of households reduced their non food expenditures, 64.3% of households reported spending their savings, 48.9% pawned gold, while 34.2% of households borrowed money or food from friends or relatives due to lack of food or money to buy food. Overall, these four-negative coping strategies are the most frequently used by households, followed by looking additional income (15.3%).

11.4 Iodine levels in salt samples from households

Salt samples from each household were collected to determine the iodine level by the titration method. A total of 2287 salt samples were available for analysis.

As shown in Table 11.1, the median iodine content was higher than the required 15 parts per million (PPM) in all provinces. The lowest median salt iodine levels were seen in the North Central province (16.9 ppm) and the highest, in the Sabaragamuwa province (19.8 ppm).

Table 11.1: Level of iodine in salt at household level by provinces and sector

Province	No. of salt samples	Median (ppm)	25^{th} – 75^{th} percentile
Western	402	18.0	13.8 - 22.4
Southern	303	19.0	15.9 - 23.0
Central	339	19.0	15.0 - 23.0
Northern	213	19.0	13.8 - 24.3
Eastern	209	18.0	13.9 - 22.2
Northwestern	231	18.0	13.8 - 22.2
North Central	166	16.9	11.6 - 23.3
Uva	211	18.0	11.6 - 21.2
Sabaragamuwa	217	19.8	15.9 - 23.3
Sector			
Urban	292	18.0	13.8 - 23.3
Rural	1803	18.2	14.0 - 23.0
Estate	196	19.0	15.9 - 23.3
Sri Lanka	**2291**	19.0	**14.0 - 23.0**

As shown in Table 11.2, only 2.2% of samples were not iodized and 26.4% were inadequately iodized with 5-14.9 ppm. The highest percentage of samples with no iodine or inadequate iodine content (< 15.0 ppm) was reported from the North Central Province (36.7%) and the lowest from the Sabaragamuwa province (19.8%). For all samples, 66.5% had iodine levels within the permitted range, i.e., 15-30 ppm. It was observed that 5.2% of salt samples had iodine values higher than the permitted range (above 30 ppm), this percentage being highest in Northern province (10.8%) and lowest in Eastern province (1.4%). Overall, 71.8% of households were using adequately iodised salt according to the global recommendations (>15ppm).

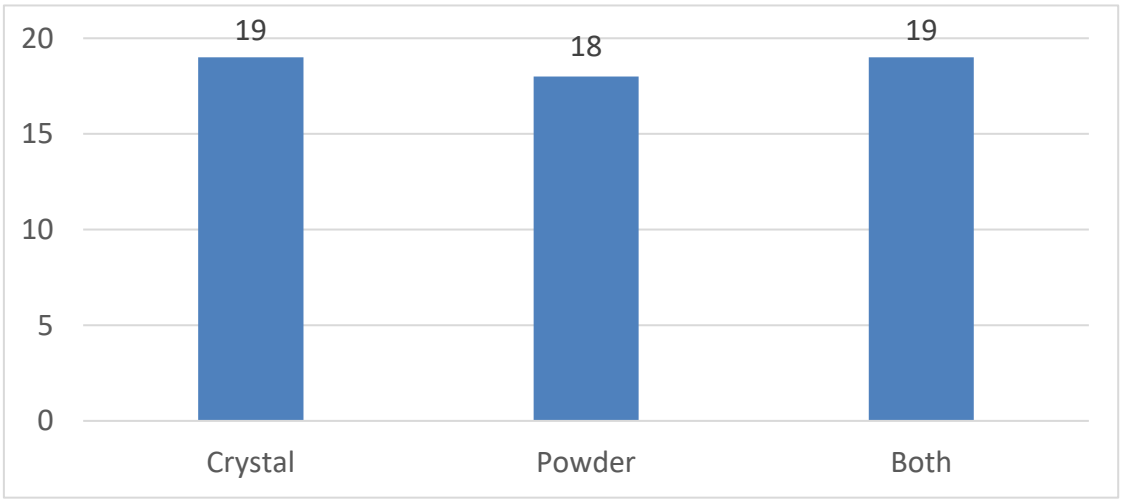
Table 11.2: Frequency distribution of iodine level in salt at household levels by provinces

Province	No iodine (< 5 ppm)	Inadequate iodine (5-14.9 ppm)	Adequate Iodine (15-30.0 ppm)	Excess iodine (> 30 ppm)	No.
Western	2.2	29.2	63.2	5.2	400
Southern	1.7	20.5	72.9	5.0	303
Central	0.9	20.7	71.9	6.5	338
Northern	3.3	25.5	60.4	10.8	212

Eastern	3.3	26.8	68.4	1.4	209
Northwestern	0.9	29.9	65.4	3.9	231
North Central	3.6	36.7	53.0	6.6	166
Uva	5.2	31.3	60.2	3.3	211
Sabaragamuwa	0.5	19.8	76.5	3.2	217
Sri Lanka	**2.2**	**26.1**	**66.5**	**5.2**	**2281**

Figure 11.7 shows the iodine content of the type of salts used by households.

Figure 11.7: Median iodine content of type of salt in households



CHAPTER 12: CONCLUSIONS AND RECOMMENDATIONS

12.1 Conclusions

The findings of this study indicate wasting of children aged 6-59 months is a critical public health problem. There is a need to address the high prevalence of wasting urgently. Overweight and obesity is an emerging public health problem among all the age groups including pregnant women during the first trimester.

This study has identified that the micronutrient deficiencies are still public health problems among children, non-pregnant, men, and pregnant women. In general, the iron levels in all population groups that studied could be considered as satisfactory. However, this study also shows the relatively high prevalence of vitamin D deficiency in all studied age groups indicating the need for attention to improving vitamin D intake among all groups. It was observed that zinc deficiency and vitamin B_{12} deficiencies are emerging micronutrient problems. Median urinary iodine concentrations were below the optimum levels in all age groups except children aged 5-9 years indicating an urgent necessity to revisit the salt iodisation programme in the country.

This study showed that factors other than iron deficiency are causes of anaemia in all age groups, especially zinc deficiency and vitamin B_{12} deficiency. In view of the ongoing preventive programmes focusing mainly on iron supplementation, it is necessary to review these programmes, which need to be supported by in-depth research on the causes of anaemia. The assessment of association between food intake and anaemia, zinc deficiency, vitamin B_{12} deficiency has to be studied, both in terms of food groups as well as the amount and pattern of intake. Inter provincial variations in anaemia, iron deficiency, zinc deficiency, vitamin D deficiency, vitamin B_{12} deficiency and other contributory factors to these deficiencies have to be taken into consideration in developing appropriate interventions at the provincial level.

High level of food insecurity at household level is a concern. Currently many coping mechanisms are used to manage the situation.

12.2 Recommendations

The following recommendations have been given below based on the findings of the study.

1. Need an urgent action to manage wasted children aged 6-59 months and to prevent further deterioration.
2. The burden of zinc, iodine and vitamin D deficiencies are quite higher in children and pregnant women. A separate program should be considered to mitigate the burden at the population level.
3. The evidence generated from the study suggests that multiple micronutrient deficiencies are prevalent in children (6-59 months, 5-9 years of age) and pregnant women. Provision of multiple micronutrients through food or as supplements is an urgent intervention to consider.
4. Zinc deficiency is increasing compared to 2012 data, which warrants rethinking of a program to improve zinc status in both children and pregnant women.
5. Including Vitamin D supplementation should be considered for strengthening the micronutrient supplementation programs for the pregnant women. Therefore, it is recommended that multiple micronutrient supplementation instead of iron folic acid

supplementation to pregnant women. Need to increase the awareness on sunlight and vitamin D.

6. A strong policy is needed to enhance the food fortification programmes and utilization of fortified food in collaboration with private sector.
7. Establishment of surveillance programmes are crucial to monitor the nutritional status and progress of nutrition program. A small survey is necessary following the sampling frame of the current study to understand the trends of the malnutrition.
8. The new evidence will provide direction to modify the existing nutrition program and to take a new program for children and pregnant women.
9. A nationwide study is crucial to understand the aetiology of anaemia and geographical variations of micronutrient deficiencies in children and pregnant women.
10. Food vouchers need to be distributed to food insecure households with wasted and stunted children.
11. Establish the surveillance programme to improve the iodine status of the population liaising with salt producers.
12. Need the vulnerability mapping to identify the most vulnerable households.

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