DAILY RECOMMENDATIONS AND FOOD FORTIFICATION
Globally, 2 million people, and nearly half of India’s population suffer from micronutrient malnutrition, with consequences that include acute anaemia, cognitive delays, weakened immune system and increased risk of birth defects. It affects all sections of India’s population - urban and rural, rich and poor, old and young - with women and children most at risk.

Food Fortification is one of the most effective, scalable, affordable and sustainable ways to address micronutrient deficiencies. It complements dietary diversification to help complete a person’s daily nutritional needs. It fills the gap in nutrition in an easy manner without any change in taste, texture or flavour of food, minimising the need for behaviour change.

The main purpose of this document is to assist States/UTs to educate people about the health benefits of fortification program and in the process clarify any queries that they may have regarding fortification and daily consumption of a diverse diet. This document will provide answers to the prime concerns revolving around food fortification; why fortification and is it safe to consume a fortified diet? We are all committed to the elimination of micronutrient malnutrition and with fortification the journey could be accomplished soon. As major line ministries have mandated the use of fortified staples in major food programmes of the country, we hope that this document will help the State/UTs to meet this goal and therefore enable citizens to achieve their full social and economic potential.

This document further elaborates on the difference in the average consumption of micronutrients such as Vitamin A, Vitamin D, Iron, Folic Acid and Vitamin B12 which are consumed in a regular diet when compared with inclusion of fortified staples. The document is organized according to different age groups, gender and the level of physical activity. It captures the nutrient requirement of an individual, needs fulfilled by a regular diet and a fortified diet along with estimated average requirements, recommended dietary requirements and toxicity levels of different nutrients. This document is evolving as it’s based on the recent RDA guidelines 2020 released by ICMR, NIN.

The Ministry of Health and Family Welfare has been appointed as the nodal ministry by the PMO for all purposes of fortification via the Food Safety Standards Authority of India. To promote large scale food fortification as a supplementary strategy to address micronutrient
deficiencies, the Food Fortification Resource Centre (FFRC) has been set up in FSSAI. The FFRC works with various government partners and development agencies to assist in implementation of directives issued by MWCD, MHRD and DoFPD.

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Executive Summary

Food fortification is one of the most effective, scalable, affordable and sustainable means to address micronutrient malnutrition. But there is always a concern among the population about the safe levels associated with the consumption of these fortified staples in their diets. This document aims to highlight the intake of nutrients via foods – both indigenously and via fortified staples. The intake of 6 nutrients namely Vitamin A, Vitamin D, Iron, Folates, Vitamin B 12 and Iodine throughout the lifecycle have been estimated using the Indian Food Composition Tables (IFCT, 2017).

A comparative analysis has been carried out w.r.t intake of these nutrients from an ideal intake of food groups and the additional intake from fortified staples. The intakes have been compared with the Estimated Average Requirements (EAR), Recommended Dietary Allowances (RDA), and Tolerable Upper Limit (TUL) of these respective micronutrients (ICMR, 2020).

The document highlights the results in two parts:

a) It provides comparison of the percentage increase in the RDA between non fortified staples vs fortified staples.

b) It compares a day’s diet of an individual from diverse diet via local, seasonal produce vs fortified sources. It also compares against EAR, RDA and TUL markers to present a complete picture.

In the formulation of this document, ideal intake of various food groups has been based on the Indian Dietary Guidelines (ICMR, 2010 & 2020). While considering the intake of these nutrients through a balanced diet, it was observed that the RDA of certain nutrients in certain age groups could be achieved by consuming foods rich in those nutrients, without consuming the fortified staples. But it is important to note that the real life situation is very different from this ideal scenario. Consumption data indicates that Indian diets are deficient in various macronutrients and the micronutrient quality index of these diets is also very low. Apart from this, lack of nutrition education, incorrect cooking and eating practices, poor bio-availability of nutrients, myths and beliefs of various population groups, food insecurity and other environmental and financial constraints further lead to consumption of nutrient deprived diets.

Thus, in order to meet the requirements of certain micronutrients, higher amounts/quantity may be needed which can be achieved by consuming fortified staples. These fortified staples can provide that window of opportunity which would help in promoting adequate
intake of certain micronutrients which are deficient in the diets of many Indians. Since the level of fortification in each of these fortified staples is adjusted in such a manner that intake of any particular nutrient does not cross the TUL on a daily basis, it can be said that fortification is a safe method to provide nutrients to individuals in a population at a very nominal additional cost. Although the current document is based on fortification standards laid down by FSSAI it may be assumed that on basis of the new dietary recommendations for Indians, newer fortification regulations may soon follow in the near future.

Therefore, it is recommended to:

• Create awareness about the benefits of consuming fortified staples
• Promote the consumption and usage of fortified staples among all age groups
• Ensure the widespread availability of fortified staples through public distribution systems and nutrition programs run by government
• Encourage voluntary fortification practices and increasing demand by a well informed consumer

It can be seen from the report that in the case of consumption of fortified staples, there is a percentage increase of select important micronutrients as compared to the non-fortified staples. Therefore, considering the incidence of “Hidden Hunger”, consumption of fortified staples proves to be an excellent preventive, long term intervention and it also falls within the safe limits of consumption.
List of Abbreviations

EAR  Estimated Average Requirements
g    gram
GLV’s Green leafy vegetables
ICMR Indian Council of Medical Research
IFCT Indian Food Composition Tables
mcg  microgram
mg   milligram
MPCE Monthly Per Capita Expenditure
NFHS National Family Health Survey
NNMB National Nutrition Monitoring Bureau
RDA  Recommended Dietary Allowances
RE   Retinol Equivalent
TUL  Tolerable Upper Limit
UTs  Union Territories
### Contents

Preface

Executive Summary

List of Abbreviations

List of Tables

List of Figures

Background ............................................................................................................................................... 1

Rationale .................................................................................................................................................... 5

Focus on micronutrients identified for staple food fortification by FSSAI ............................................ 7

Comparative study of nutrient intake with and without fortified staples throughout the day: A lifecycle Approach ................................................................................................................. 20

Conclusion ............................................................................................................................................... 51

References ............................................................................................................................................... 53

Annexures ............................................................................................................................................... 55
List of Tables

Table 1: Effect of low and high intake of a nutrient in our body
Table 2: The quantity of food groups consumed during a day through the lifecycle

List of Figures

LIST OF FIGURES

1 INCREMENTAL NUTRIENT INTAKE WITH FORTIFIED STAPLES

1.1 Vitamin A Intake from Fortified Staples vs. Regular Staples
  Figure 1 : Among Adult Man of different Activity Levels
  Figure 2 : Among Adult Woman of different Activity Levels
  Figure 3 : Among Adult Woman with Special Conditions
  Figure 4 : Among Children of different Age Groups

1.2 Vitamin D Intake from Fortified Staples vs. Regular Staples
  Figure 5 : Among Adult Man of different Activity Levels
  Figure 6 : Among Adult Woman of different Activity Levels
  Figure 7 : Among Adult Woman with Special Conditions
  Figure 8 : Among Children of different Age Groups

1.3 Iron Intake from Fortified Staples vs. Regular Staples
  Figure 9 : Among Adult Man of different Activity Levels
  Figure 10 : Among Adult Woman of different Activity Levels
  Figure 11 : Among Adult Woman with Special Conditions
  Figure 12 : Among Children of different Age Groups

1.4 Total Folates Intake from Fortified Staples vs. Regular Staples
  Figure 13 : Among Adult Man of different Activity Levels
1.5 Vitamin B12 Intake from Fortified Staples vs. Regular Staples

Figure 17 : Among Adult Man of different Activity Levels
Figure 18 : Among Adult Woman of different Activity Levels
Figure 19 : Among Adult Woman with Special Conditions
Figure 20 : Among Children of different Age Groups

2 COMPARATIVE STUDY OF NUTRIENT INTAKE WITH AND WITHOUT FORTIFIED STAPLES THROUGHOUT A DAY: A LIFECYCLE APPROACH

2.1 Vitamin-A Intake in a day’s Diet with and without Fortified Staples

Figure 21 : Among Adult Man of different Activity Levels
Figure 22 : Among Adult Woman of different Activity Levels
Figure 23 : Among Adult Woman with Special Conditions
Figure 24 : Among Children of different Age Groups
Figure 25 : Among Girls of different Age Groups
Figure 26 : Among Boys of different Age Groups

2.2 Vitamin-D Intake in a day’s Diet with and without Fortified Staples

Figure 27 : Among Adult Man of different Activity Levels
Figure 28 : Among Adult Woman of different Activity Levels
Figure 29 : Among Adult Woman with Special Conditions
Figure 30 : Among Children of different Age Groups
Figure 31 : Among Girls of different Age Groups
Figure 32 : Among Boys of different Age Groups

2.3 Iron Intake in a day’s Diet with and without Fortified Staples

Figure 33 : Among Adult Man of different Activity Levels
Figure 34 : Among Adult Woman of different Activity Levels
Figure 35 : Among Adult Woman with Special Conditions
Figure 36 : Among Children of different Age Groups
Figure 37 : Among Girls of different Age Groups
Figure 38 : Among Boys of different Age Groups

2.4 Total Folates Intake in a day’s Diet with and without Fortified Staples
Figure 39 : Among Adult Man of different Activity Levels
Figure 40 : Among Adult Woman of different Activity Levels
Figure 41 : Among Adult Woman with Special Conditions
Figure 42 : Among Children of different Age Groups
Figure 43 : Among Girls of different Age Groups
Figure 44 : Among Boys of different Age Groups

2.5 Vitamin B12 Intake in a day’s Diet with and without Fortified Staples
Figure 45 : Among Adult Man of different Activity Levels
Figure 46 : Among Adult Woman of different Activity Levels
Figure 47 : Among Adult Woman with Special Conditions
Figure 48 : Among Children of different Age Groups
Figure 49 : Among Girls of different Age Groups
Figure 50 : Among Boys of different Age Groups
The Large-Scale Food Fortification programme aims at enhancing the quality of food available by adding back the nutrients that are lost during processing or adding additional nutrients to make the staple food commodities healthier. The purpose is to encourage consumption of healthy foods, so that more than half of the Indian population obtain essential micronutrients namely Iron, Vitamin-A, Vitamin-D, Iodine, Folic Acid, and Vitamin B12 to address the incidence of micronutrient malnutrition across the age groups and the economic strata.

Food fortification is not a new idea in India. Fortification of Vanaspati was mandated in 1953 and iodization of salt was mandated in 1962. In order to achieve targeted outcomes over the next five years (2022), envisioned by the National Nutrition Strategy, 2017 and other major flagship programmes like Anaemia Mukt Bharat and POSHAN Abhiyaan, food fortification has been identified as one of the key strategies for implementation.

The programme is a generalized approach, a population based, cost effective, preventive strategy, which aims to improve the nutritional status of all Indians and not just the high risk groups, while ensuring physical and economic access for all socio-economic and vulnerable groups. The goal of the food fortification programme is to preferably combat micronutrient malnutrition that is prevalent in the masses.

Expected contribution of fortified products to the diet of the target groups based on the recommendations of the ICMR’s per day requirements and the consumption pattern of the vehicles selected for fortification are considered and the proposed standards for fortification, the anticipated contribution of the programme will provide at least 1/3 of the Recommended dietary allowances in case of Iron, Vitamin A, Vitamin D, Folic Acid and Vitamin B12.

The wide variety of foods we consume differs in its nutrient distribution. The supply of nutrients to the human body not only depends on the amount of nutrient in a food, but also on its bioavailability. The proportion of these nutrients accessible by the body for absorption and utilization through normal metabolic pathways is termed as Bioavailability. The bioavailability of nutrients is highly variable and can be influenced by numerous factors.
Expressed as a percentage, bioavailability is determined by the entire systemic fate of an ingested nutrient influenced by few important factors; viz

- Dietary factors such as concentration of nutrient
- Chemical form
- Presence of anti-nutrients in foods (phytates, oxalates, tannins, etc.)
- Cooking methods and nutrient–nutrient interactions (Ex. Calcium inhibits the absorption of Iron, Vitamin C increases iron absorption)

Various processing techniques; such as, heating, soaking, grinding, germination/malting, fermentation etc. are utilized to prepare the processed foods, & can have a substantial influence on the mineral bioavailability. Minerals are removed/reduced irreversibly during food processing. The heat treatments; such as, boiling, drying, frying, pressure cooking, steaming and sterilization can meaningfully decrease/destruct some macro - (Ca, Mg, P, K, Na) and micro - (Fe, Zn, Cu, Mn) minerals.

Host factors such as gender, age, stage of life, physiologic state, nutrition and health status and coexisting pathologic conditions all of which govern the bioavailability of nutrients. Gender and age also plays a major role as during adolescence in girls’ peak calcium absorption and calcium deposition in bones occur at or near menarche, which illustrates the importance of the physiologic state on mineral bioavailability. Similarly, during pregnancy, absorption of iron and various other nutrients is increased to cater the needs of growing foetus as well as the mother.

Physiological factors include; the release of the nutrient from the physicochemical dietary matrix; availability of digestive enzymes; the effects of luminal and mucosal digestion; binding and uptake by the intestinal mucosa (Ex. Intrinsic factor for B12 absorption); transfer across the gut mucosa to the portal, systemic, or lymphatic circulation; systemic distribution; systemic deposition; metabolic and functional use, storage; and excretion.
Why invest in nutrition?

Contrary to popular perceptions, micronutrient deficiency is not simply a result of food insecurity; many people in food-secure environment and from non-poor families are suffering from nutrient deficiencies because of proper balanced diet and low bioavailability of nutrients.

Food fortification refers to the addition of micronutrients to foods. It focuses on increasing the content of one or more target micronutrients in the food and this is predominantly done during food processing and value addition. It aids in easy access to achieving daily nutritional needs for rural communities without dependency on pharmaceutical supplements and has the potential to impact a large number of people in a cost-effective manner. The benefits being potentially large, food fortification can be a very cost-effective public health intervention. It is also necessary to have access to and to use fortificants that are well absorbed, bioavailable and yet do not cause undesirable organoleptic changes in food in other words do not affect the sensory properties of foods and subject to normal homeostatic control is essential. The most dominant minerals to fortify various food preparations are iron, calcium, zinc and iodine. On the other hand, biofortification interventions happen at the farm-level; typically, through alterations in agronomic practices, plant breeding or biotechnological approaches. Biofortification strategies for iron fortification have the advantage of addressing large populations through advanced biotechnological techniques. However, the adoption level of this approach is limited by variations in crop yield, impact on agronomic factors and acceptance by farmers.

Can fortification cause toxicity?

Tolerable Upper Limit (TUL) is the maximum level of habitual intake from all sources of a nutrient or related substance judged to be unlikely to lead to adverse health effects in humans.

The increased availability and consumption of fortified (many with multiple micronutrients) foods and food supplements has sparked concerns regarding excessive intake of nutrients. It is important to assess the safety of fortification by comparing eventual micronutrient intakes with the TUL. The safety of fortification by comparing the total micronutrient intake from all sources (natural and fortified food; supplements) with the TUL. In principle, high levels of micronutrient additions should be avoided even if a micronutrient has no recommended TUL, particularly if there is no evidence of derived benefit from levels of intake in excess of the RDA. Examples of adverse effects occurring due to both extremes of intakes could be observed in Table 1.
Table 1: Effect of low and high intake of a nutrient in our body and TUL levels

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Intake below RDA</th>
<th>Intake if greater than TUL</th>
<th>TUL levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>Anaemia</td>
<td>GI side effects</td>
<td>45mg/day</td>
</tr>
<tr>
<td>Folic Acid</td>
<td>Megaloblastic Anaemia</td>
<td>Masking of vitamin B12</td>
<td>1000mcg/day</td>
</tr>
<tr>
<td>Vitamin B12</td>
<td>Reduction in formation of RBCs</td>
<td>No studies yet</td>
<td>not defined</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>Ocular lesion, morbidity, mortality</td>
<td>Liver damage, teratogenecity</td>
<td>3000mcg RE /day</td>
</tr>
<tr>
<td>Vitamin D</td>
<td>Skeletal Deformities</td>
<td>hypercalcemia</td>
<td>4000 IU/day</td>
</tr>
</tbody>
</table>

Source: NIN, ICMR 2020

My Plate for the Day

Source: NIN, ICMR 2018
Rationale

Nutrition based strategies to improve the status of the population includes consuming a diverse diet in a balanced manner. In the recent times, with either lack of food security or diet patterns, sufficient nutrient intake is compromised. Food fortification is the process of increasing the content of essential micronutrients, that is, vitamins or minerals in a food, irrespective of whether the nutrients were originally in the food before processing or not, so as to provide a health benefit with minimal risk to health. Fortification does not alter the colour, taste, odour, and appearance of the carrier food.

There is always a concern that if we consume fortified food in our diet then it might lead to toxicity of the micronutrient in our body. This document captures the nutrient needs throughout the lifecycle with comparative analysis of a reference diet of an individual with and without consumption of fortified staples. It focusses on the micronutrients that are added in the fortified staples to study the level of toxicity which include Vitamin A,D, B12, Folate, Iron and Iodine as well as provides an overview of the diet in comparison with the EAR, RDA and TUL for a micronutrient as well.

Table 2 placed at Annexure 1 provides the sample days diet for different age, sex and physical activity level considered while calculating the nutrient intake from the diet. The following considerations are taken for calculating a day’s diet:

- 100 g of GLVs (spinach, fenugreek, drumstick leaves and mustard) have 21.45 g of phytates. Phytates are anti-nutrient as they bind minerals like iron in the digestive tract making them less metabolically available for absorption (IFCT, 2017).

- The average household consumption of various food stuffs as % of the RDA was 69.6% (cereals), 104.5% (pulses), 59% (GLVs), 125.7% (other vegs.), 188% (roots and tubers), 81.3% (meat and meat products) and 52.3% (sugar and jaggery). This further highlights an important aspect that consumption patterns will further impact the availability of nutrients (NNMB, 2017).

- Average protein intake per capita per day was seen to rise steadily with MPCE (Monthly Per Capita Expenditure) level in rural India from 43gm for the bottom 5% of population ranked by MPCE to 91gm for the top 5%, and in urban India from 44gm for the bottom 5% to about 87gm for the top 5%. The share of milk and milk products in protein intake was 10% in rural India and 12% in urban India. The share of meat, fish and egg in protein intake was only 7% in rural India and 9% in urban India (NNMB, 2017).

- Dietary vitamin B12 values have been obtained from the Nutritive Value of Indian Foods (1989) as the new IFCT (2017) does not include these values.
• Vitamin D is expressed in mcg as IFCT (2017) have all the calculations based on the unit.

• The levels of fortification are as per the current standards of FSSAI and which may be revised according to the new RDA (2020). The document will be revised accordingly in the next version.

• Since the wheat flour, maida and rice are the only cereals fortified currently so the average is taken for the calculation.

• According to RDA (2020) studies clearly show that there is a shift in physical activity from active to inactive. The population with heavy activity is not performing intense activity continuously for 8 hrs. It should be mentioned however, that proportion of population engaging in heavy work is quite small. Thus, the same category is not considered for calculations.

• The Food Safety and Standards (Fortification of Foods) Regulations, 2018 have been notified in the Gazette of India on 2nd August 2018 which replace the standards operationalised earlier. The new standards now provide a minimum and a maximum range for fortification of staples like wheat flour (atta), maida, rice (with Iron, Folic Acid and Vitamin B12), double fortified salt (with Iodine and Iron), vegetable oil and milk (with Vitamin A and Vitamin D); the dosage of the micronutrients has been adjusted so that they provide 30 to 50 percent of the daily requirements. In Wheat Flour and Rice fortification, bioavailable sources of Iron have been added.
FOCUS ON MICRONUTRIENTS IDENTIFIED FOR STAPLE FOOD FORTIFICATION BY FSSAI
Introduction

As per National Family Health Survey-4 (2015-16), public health concerns like Iron deficiency Anaemia is still prevalent in over 50 per cent of women (15-45 years) and children under 5 years of age. As per the selected state-wide surveys conducted by the National Nutrition Monitoring Bureau (NNMB) of National Institute of Nutrition (NIN), Govt. of India, almost 62% of Indian population has low serum blood levels of vitamin A and 50%-94% of people in different states across India, suffer from vitamin D deficiency. Adverse functional outcomes like stunting, increased susceptibility to infectious diseases, physical impairments, cognitive losses, blindness and premature mortality are caused because of micronutrient deficiency.

The CNNS, 2019 provides national and state-level data on malnutrition and six micronutrient deficiencies among children and adolescents along with biomarkers for non-communicable diseases among the 5-19-year-old population. The report states Anaemia and iron deficiency is one-fold higher in girls than boys. Every third adolescent girl is folate deficient, boys have higher folate deficiency than girls in 15-19 years group.

Food fortification is a complementary strategy and not a replacement of balanced, diversified diets to address malnutrition. Dietary diversification is indeed the best choice but in the current scenario it may be difficult to achieve by everyone, therefore a more universal approach is needed to address the issue. Dietary diversification, supplementation and food fortification are not “Either / Or” choices but “Complementary strategies”. Fortification only bridges the gap between the need and actual consumption of required micronutrients through food.
1.1 Vitamin A Intake from Fortified Staples vs. Regular Staples

The consumption of fortified staples increases the average intake of Vitamin A by 99% compared to the non-fortified diet in the case of an Adult Male Sedentary and Moderate Worker. Figure 1 shows that nearly \( \frac{1}{2} \) to \( \frac{3}{4} \)th EAR (460 mcg RE/ day) of Vitamin A is met through the consumption of fortified staples. It is also evident that regular staples completely lack Vitamin A and can lead to deficiency in the longer run.

In case of Adult Woman, there is a rise of 98% as seen in Figure 2 as a result of consumption of fortified staples. For a Moderate Worker, more than \( \frac{1}{2} \) of EAR is achieved with fortified staples giving 228 mcg RE Vitamin A per day. Along with Vitamin A rich fruits & vegetables, the RDA (840 mcg RE/day) can be easily achieved.
Pregnancy is a period of increased requirement of nutrients for a woman so as to supply to the growing foetus adequately. Figure 3 shows that consuming fortified staples can further help in meeting EAR of Vitamin A with an intake of 297 mcg RE. On the other hand, fortified staples can increase Vitamin A intake by 91% (460 mcg RE) for a lactating mother.

Vitamin A intake with the consumption of fortified staples among children in the age group 1 – 3 years, 4 – 6 years and 7 – 9 years increases intake by 90%, 90% and 91% respectively.

Among girls, in the age group of 10 – 12 years, 13 – 15 years and 16 – 18 years, consuming Vitamin A fortified staples gives an additional of 92%, 92% and 91% respectively, owing to a total intake of 500.67 mcg RE, 540.61 mcg RE and 500.9 mcg RE/ day respectively from fortified staples.

Among boys, in the age group of 10 – 12 years, 13 – 15 years and 16 – 18 years, consuming fortified staples gives an additional of 92%, 93% and 93% respectively of Vitamin A, owing to a total intake of 500.81 mcg RE, 580.16 mcg RE and 620.26 mcg RE/ day respectively from fortified staples (Refer Figure 4).
While Sunlight has proven to be the ultimate source of Vitamin D for many years, it has been a challenge for the desk job personnel to meet their Vitamin D requirements through regular diet. Figure 5 shows consumption of Vitamin D fortified staples increases their average intake by 26 – 29%.
Bone health for a woman is achieved not just by the intake of Calcium but also with good quality Vitamin D which could be obtained from fortified staples. As shown in Figure 6, they seem to raise the intake for a sedentary (by 26%) and moderate (24%) worker respectively.

As seen in Figure 7, an increased intake of 21% and 28% respectively can be achieved in the case of a pregnant and lactating woman with fortified staples. The average raise in intake with fortified staples is seen to be 4.52 mcg and 7.7 mcg/day in pregnant and lactating woman’s diet which is well above the EAR and RDA.

Vitamin D intake with the consumption of fortified staples among children in the age group 1 – 3 years, 4 – 6 years and 7 – 9 years increases intake by 62%, 45% and 37% respectively.
Among girls, in the age group of 10 – 12 years, 13 – 15 years and 16 – 18 years, consuming Vitamin D fortified staples gives an additional of 33%, 28% and 26% respectively, owing to a total intake of 23.93 mcg, 30.675 mcg and 30 mcg/ day respectively from fortified staples.

Among boys, in the age group of 10 – 12 years, 13 – 15 years and 16 – 18 years, consuming fortified staples gives an additional of 28%, 25% and 24% respectively of Vitamin D, owing to a total intake of 27.99 mcg, 37.39 mcg and 35.5 mcg/ day respectively from fortified staples (Refer Figure 8).

1.3 Iron Intake from Fortified Staples vs. Regular Staples

Consumption of Fortified staples can help an adult man moderate worker achieve his daily requirement of Iron 19mg/ day. Fortification leads to an intake rise of 58% (9.7mg) and 38% (10.7mg) respectively in an adult man sedentary and moderate worker (Figure 9).
It is difficult to achieve Iron RDA from a diet consisting of non-heme iron sources unless and otherwise it is fortified. In Figure 10, it is seen that fortified staples can increase iron intake by 57 – 62% in an adult woman. This intake helps to achieve 47 – 61% of RDA (29mg/ day) especially in case of moderately working woman fortified staples consumption helps cross the EAR line of 15mg/ day giving an average intake of 17.8 mg of Iron. As per NFHS IV data 2015-16, Anaemia prevalence is 53.1% among woman of reproductive age group and iron fortification can prove to be a key factor in reducing the prevalence of Anaemia.
Pregnancy is a period of increased requirement of Iron 40mg/day. Food fortification helps to meet 40% of RDA and 50% of EAR for a pregnant woman. Iron deficiency during pregnancy can lead to serious complications in the growth & development of foetus. Consuming iron fortified diet can raise the iron intake by 59% and 56% in a pregnant and lactating woman respectively as shown in Figure 11.

Iron intake from the consumption of fortified staples among children in the age group 1 – 3 years, 4 – 6 years and 7 – 9 years increases by 20%, 38% and 39% respectively. Figure 12 shows that among girls, in the age group of 10 – 12 years, 13 – 15 years and 16 – 18 years, consuming iron fortified staples gives an additional of 59%, owing to a total intake of 15.566 mg, 18.27 mg and 18.27 mg/ day respectively from fortified staples.

Among boys, in the age group of 10 – 12 years, 13 – 15 years and 16 – 18 years, consuming fortified staples gives an additional of 56%, 53% and 54% respectively of iron, owing to a total intake of 18.11 mg, 23.068 mg and 22.23 mg/ day respectively from fortified staples.
1.4 Total Folates Intake from Fortified Staples vs. Regular Staples

Folates are available from various fresh fruits & vegetables and fortification has helped in their even easier availability from staples. An increased intake of 26% (27.5mcg) and 27% (36.02 mcg) is obtained from an adult man's diet consisting of folate fortified staples (Figure 13).

Figure 13

Figure 14
Folic acid deficiency can also contribute to the increasing burden of Anaemia. By consuming fortified staples, an adult woman can obtain 24% - 26% (Figure 14) increased folic acid in their diet excluding other sources. This helps to meet 51% of their RDA and 63% of EAR for Folates.

During pregnancy, folic acid deficiency can cause Neural Tube Defects. Figure 15 show that Folic Acid from fortified staples can increase the intake by 23% (30 mcg) in the case of both pregnant and lactating woman.
1.5 Vitamin B12 Intake from Fortified Staples vs. Regular Staples

Consumption of Vitamin B12 fortified cereals can increase the intake by 40% in adult man sedentary worker and by 46% in moderate worker. It contributes to 35% of RDA which is an added value since Vitamin B12 vegetarian sources are fairly low (Figure 17).
Vitamin B12 intake from fortified staples among adult women of both sedentary and moderate categories is seen to be 0.62 mcg and 0.72 mcg respectively. Figure 18 shows that fortification alone contributes to an intake rise of 32% and 42% among women. It helps to meet approximately 25 - 30% of RDA.

Food fortification with Vitamin B12 can increase the consumption by 35% and 30% in pregnant and lactating women respectively. As seen in Figure 19, this helps to meet 29% of RDA (2.75 mcg) for a pregnant woman and also 29% RDA (3.5 mcg) for a lactating woman.
Vitamin B12 intake among children in age group 1 – 3 years and 4 – 6 years with a RDA of 1.2 mcg/ day is seen to increase by 8% and 15% respectively, for 7 – 9 years with RDA 2.5 mcg/d, the intake increases by 20% with the consumption of fortified staples (refer Figure 20).

Among girls, in the age group of 10 – 12 years, 13 to 15 years and 16 – 18 years, consuming fortified cereals gives an additional of 30%, 26% and 38% respectively of Vitamin B12, owing to a total intake of 1.2 mcg, 0.94 mcg and 1.12 mcg/ day respectively just from fortified staples. This intake helps to meet approximately 43% of RDA and 54% of EAR.

Among boys, in the age group of 10 – 12 years, 13 to 15 years and 16 – 18 years, consuming fortified cereals gives an additional of 32%, 39% and 32% respectively of Vitamin B12, owing to a total intake of 1.03 mcg, 1.15 mcg and 1.03 mcg/ day respectively. This intake helps to meet approximately 43% of RDA and 54% of EAR. Thus fortification of Vitamin B12 staples helps in achieving RDA along with the consumption of other Vitamin B12 rich sources.
COMPARATIVE STUDY OF NUTRIENT INTAKE WITH AND WITHOUT FORTIFIED STAPLES THROUGHOUT THE DAY

A LIFECYCLE APPROACH
2.1 ADULT MAN

Adulthood requires health maintenance and disease prevention. As an informed consumer, it is upon the adults to make cognizant choices to opt for healthy diets. This is a period where adequate nutrition is critical for overall well-being and therefore the diets should include all nutrients in their required amounts.

The following sections highlight the various micronutrients required by an adult man wrt various activity levels.
Vitamin A:
As observed in Figure 21 in sedentary male the approximate intake of vitamin A through a balanced diet could be 1502.41 to 1596.41 mcg RE without fortification. Fortified foods add an additional 279.3 mcg of vitamin A in a day taking the intake around 1781.94 to 1875.71 mcg RE after consuming fortified foods. In moderate male worker the approximate intake of vitamin A through a balanced diet could be approximately 1501.93 to 1600.93 mcg RE without fortification. Fortified foods add an additional mcg of vitamin A in a day taking the intake around 334.05 mcg RE after consuming fortified foods. Even after this additional amount the total intake is much below the tolerable upper limit of 3000mcg RE /day for an adult male with different physical activity level.
Vitamin D:

Figure 22 highlights the intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 77.35 mcg/day in a sedentary adult male. Fortification provides an additional intake of 7.375 mcg/day. In a moderate worker a day’s diet provides around 88.672 mcg/day and fortified staples provides an additional intake of 8.325 mcg/day. The TUL for vitamin D is 100 mcg/day. However, this is based on the assumption that adult males consume the balanced proportions of all food groups as suggested by ICMR. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. Hence, the diet would provide only 28.24 mcg/day in sedentary worker and 32.33 mcg/day in a moderate worker which is within safe limits.

Iron:

Iron intake via a balanced meal could be approximately 20.02 to 22.18 mg/day for a sedentary male and 23.59 to 24.5 mg/day for a moderate worker which would be sufficient to meet the RDA (19mg/day) (as seen in Figure 23). The intake of iron has been calculated keeping in mind the richest sources of iron and this indicates the maximum an adult man could consume via diet. However, the actual intake is much lower and is not able to meet the demand. This justifies the fortification which adds about 9.715 mg in sedentary male and 11.215 mg in moderate worker of iron in a day.

Even if we consider that actual intake is in the range of 23.5 – 24.5 mg/day (the best case scenario), for a moderate worker fortification would make the total intake to be around 35.72 - 37.88 mg/day. The TUL for iron is 45mg/day.
Folic Acid:

Folic acid is obtained mainly from vegetarian sources and if a balanced diet is consumed, one can have an intake of 499.98 – 603.25 mcg/day for a sedentary male (refer Figure 24). Fortification provides an additional 27.5 mcg/day. Similar calculations can be observed for a moderate worker with an average intake of 594.09 – 618.77 mcg/day from natural sources. Fortification provides an additional 36.02 mcg/day and this is well within the safe TUL of 1000 mcg/day. Folic acid is a water-soluble vitamin and any excess would be discarded by the body.
Vitamin B12:

Dietary vitamin B12 values have been obtained from the Nutritive Value of Indian Foods (1989) as the new IFCT (2017) does not include these values. However, Vitamin B12 values of only 2 food sources i.e. milk and egg have been included in these. As per these 2 values the intake would range from 0.42 to 1.32 mcg/day for a sedentary male. Fortification adds another 0.28 mcg/day. For a moderate worker intake would range from 0.42 to 1.32 mcg/day. Fortification adds another 0.36 mcg/day. The TUL values of vitamin B12 are not available but assuming this is a water-soluble vitamin, toxicity levels would be quite high. (refer Figure 25)
2.2 ADULT WOMAN

The essentials of a healthy diet are similar for men and women. Although the recommended breakdown of carbohydrate, protein, and fat are the same for both genders, because men generally need more calories, they also require higher total intake of each of the macronutrients.

Though women need fewer calories than men, but in many cases, they have higher vitamin and mineral needs. Adequate intake of calcium, iron, and folic acid are of special importance for women. Due to the hormonal changes associated with menstruation and child-bearing, women are more susceptible than men to weakened bones and osteoporosis. Women also are at increased risk of iron-deficiency anaemia compared to men due to the monthly blood loss associated with menstruation.
Vitamin A:

As observed from Figure 26 Sedentary Women the approximate intake of vitamin A through a balanced diet could be 1502.52 – 1596.37 mcg RE without fortification. Fortified foods add an additional 169.8 mcg of vitamin A in a day taking the intake around 1672.32 to 1766.17 mcg RE after consuming fortified foods. In a moderate worker the intake of vitamin A through a balanced diet could be approximately 1503.72 – 1597.57 mcg RE without fortification. Fortified foods add an additional 224.5 mcg of vitamin A in a day taking the intake around 1728.22 – 1822.07 mcg RE after consuming fortified foods. Even after this additional amount the total intake is much below the tolerable upper limit of 3000 mcg RE/day.
Iron: 

Iron intake via a balanced meal could be approximately 18.26 – 20.42 mg/day, which would be sufficient to meet the RDA. However, our intake is much lower and is not able to meet the demand. This justifies the fortification which adds about 8.415 mg of iron in a day. Even if we consider that actual intake is in the range of 18 mg/day (the best case scenario), fortification would make the total intake to be around 26.675 to 28.84 mg/day.

The fortification adds about 10.195 mg of iron in a day diet of moderate worker. Even if we consider that actual intake is in the range of 21.26 – 23.42 mg/day (the best case scenario), fortification would make the total intake to be around 31.45 – 33.61 mg/day. This would still be much below the TUL of 45 mg/day. Hence Fortification with iron is safe. (refer Figure 28)

Vitamin D: 

In a Sedentary worker, the intake of vitamin D in the form of cholecalciferol and ergocalciferol is estimated to be around 72.37- 78.947 mcg/day. Fortification provides an additional intake of 5.475 mcg/day. In a moderate worker, the intake of vitamin D in the form of ergocalciferol and cholecalciferol is estimated to be around 80.51 – 87.087 mcg/day. Fortification provides an additional intake of 6.425 mcg/day (refer Figure 27).

It has been reported earlier also that only a third of the ergocalciferol gets converted to Vitamin D3. Keeping that in mind, the intake via food would be only be around 24 - 26 mcg/day in sedentary and 28- 29 mcg/day in moderate worker. Consumption of fortified staples would provide 28 mcg/ day and 31 mcg/day of Vitamin D3 in a sedentary and moderate worker respectively. TUL for vitamin D is 100mcg/day. Hence this is within safe limits.
Folic Acid:

As observed from Figure 29 the folic acid is obtained mainly from vegetarian sources and of a balanced diet is consumed, one can have an intake of 485.68 – 588.95 mcg/day and 530.6 – 633.87 mcg/day for sedentary and moderate respectively. Fortification provides an additional 20.08 and 30.12 mcg/day in a sedentary and moderate worker respectively and this is well within the safe TUL of 1000mcg/day.
Vitamin B12:

Dietary vitamin B12 values have been obtained from the Nutritive Value of Indian Foods (1989) as the new IFCT (2017) does not include these values. However, Vitamin B12 values of only 2 food sources i.e milk and egg have been included in these. As per these 2 values the intake would range from 0.42 to 1.32 mcg/day. Fortification adds another 0.2 and 0.3mcg/day in sedentary and moderate worker respectively. The TUL values of vitamin B 12 are not available but assuming this is a water soluble vitamin, toxicity levels would be quite high. (Refer Figure 30)
2.3 PREGNANT AND LACTATING WOMEN (SEDENTARY)

During pregnancy, the quality of a mother’s diet and the rate of weight gain are two of the most crucial factors that influence a child's future health. An inadequate diet will place the baby at risk for developmental delays, birth defects and poor brain development. When a woman lacks sufficient folic acid before becoming pregnant and in the early weeks of her pregnancy, it can lead to birth defects of the brain and spine (neural tube defects) that can cause death or lifelong disability. According to NFHS 4 data, more than half of the women in the reproductive age are anaemic. Although the pregnant woman needs to consume a balanced diet and the requirement for all nutrients increases, nutrients which are critical during pregnancy include:

- Iodine for normal growth, thyroid and brain function
- Folic acid for foetal development and blood formation
- Iron to help fight anaemia
- Vitamin B12 for normal functioning of nervous system
- Vitamin D for supporting strong bones
- Vitamin A for prevention of night blindness

In order to support breast feeding, the mother’s body undergoes a number of physiological changes. Lactation is a period increase the maternal nutritional needs as her breast milk has to fulfil the needs of a fully developed and rapidly growing infant. Adequate nutrition is very important to ensure good health of both mother and child. The effects of any nutritional inadequacies during this period can adversely affect the total quantity of milk produced. In absence of timely and regular consumption of the iron and folic acid tablets provided during pregnancy, defaulters due to pre-existing myths in few on consumption of medications during pregnancy, at least consumption of fortified staples may help to improve the nutritional status.
Vitamin A:

In ideal conditions, intake of vitamin A via diet would be able to meet the requirements of a pregnant woman i.e 900 RE/day. However, NNMB data (2017) indicates that intake of vitamin A is grossly inadequate and populations consume only about 22.8% of the RDA. In case of pregnant women this amounts to be roughly 175 mcg RE /day. And in case of lactating women it is around 209 mcg RE/day. This is because intake of GLV’s the rich source of vitamin A is just around 60% of the recommended intake (NNMB, 2017).

Keeping this in mind fortification becomes necessary as this would add an additional 263 mcg RE/ day. This would help in increasing the level of intake substantially. However, even if we assume that intake is as per the desired specified amounts, fortification levels would still be below the TUL of 3000mcg RE/day. (As observed in Figure 31).
Vitamin D:

Vitamin D during pregnancy is highly essential as it supports foetal bone development by enhancing Calcium absorption. Figure 32 show that an average intake of Vitamin D through balanced diet would be 88.29 – 92.86 mcg/ day in a pregnant woman and 82.92 – 83.34 mcg/ day in a lactating mother. Fortification would add an extra 4.52 mcg and 7.175 mcg respectively for each category summing up the intake to 92.81 – 97.38 mcg/ day in a pregnant and 90.015 - 90.515 mcg/ day in a lactating mother, which is well above the RDA (15mcg/d) and below the toxicity upper limit (100 mcg/d).
Iron:

The requirement of iron during pregnancy is quite high i.e 40 mg/day and it is 23 mg/d during lactation. Diets, if consumed in the suggested proportions would provide 21.51 – 23.63 mg/day to pregnant women (refer Figure 33). This ideal consumption would also not be able to meet the needs.

The actual situation is that consumption of iron meets only 59% of the RDA. This is about 23.6 mg of iron/day. Other studies have indicated that iron intake on an average is just about 14 mg/day (Ghosh et al. 2019). Fortification adds roughly 9.29 mg of iron in a day. This too depends on the intake of cereals (flour and rice) which has been found to be inadequate (70% of recommended intakes, NNMB 2017). Thus fortification would be a safe way to improve the iron content during pregnancy. This would be below the TUL of 45mg/day.

In lactating women, though the RDA (23mg/d) is reduced and the ideal diet with iron content 20.94 to 21.85mg/d would be able to meet 95% requirements for a lactating woman, the actual intake is much lower. As per NNMB data, intake would be just about 16 mg/day.

![Figure 34](image)

Folic acid:

Dietary folate intake of a pregnant woman is around 553.42 – 663.59 mcg/day in an ideal balanced diet. Fortification adds another 25 mcg to it (refer Figure 34) which helps meet RDA for both a vegetarian and a non-vegetarian. In the case of lactating woman, consuming fortified foods provide 578.42 – 688.59 mcg/d which could be a reliable source to meet the folate RDA of 330 mcg/d. It is safe to consume fortified foods as the intake of folate would be way below the TUL of 1000mcg/day.
Vitamin B12:

Dietary vitamin B12 values have been obtained from the Nutritive Value of Indian Foods (1989) as the new IFCT (2017) does not include these values. However, Vitamin B 12 values of only 2 food sources i.e milk and egg have been included in these. As per these 2 values the intake would range from 0.56 – 1.46 mcg/day. Fortification adds another 0.25 mcg/day in case of pregnant and in a lactating woman fortification provides around 1 – 1.9 mcg/day. The TUL values of vitamin B 12 are not available but assuming this is a water soluble vitamin, toxicity levels would be quite high (Refer Figure 35). Thus, Vitamin B12 fortification helps to meet 62% (1.71 mcg/d) of RDA (2.75 mcg/d) for a pregnant woman and 54% (1.9 mcg/d) of RDA (3.5 mcg/d) for a lactating woman.
Nutrient requirements are high during the growing years. A child requires nutrition not just for food. Good nutrition improves the child's physical well-being as well as cognitive development, leading to better growth and academic performance. Poor eating habits often lead to prevalence of diseases during adulthood. Therefore, childhood presents with the possibility to inculcate good and safe eating habits.

By school age, children often develop particular eating habits who may be influenced by external factors. The need of a wholesome balanced diet with nutrition education becomes an important factor.
Vitamin A:

Figure 36 significantly show the exponential increase in the Vitamin A in the diet when fortified staples are consumed throughout the day. For children aged between 1-3 years the approximate intake of vitamin A through a balanced diet could be approximately 585.04 to 632.985 mcg RE without fortification. Fortified foods add an additional 378.75 mcg of vitamin A in a day taking the intake around 963.78 to 1011.74 mcg RE after consuming fortified foods. Tolerable upper limit is 600 mcg RE /day.

Children 4-6 years: The approximate intake of vitamin A through a balanced diet could be approximately 702.33 to 750.145 mcg RE without fortification. Fortified foods add an additional 378.75 mcg of vitamin A in a day taking the intake around 1081.08 to 1128.9 mcg RE after consuming fortified foods. Tolerable upper limit is 900 mcg RE /day.

Children 7-9 years: The approximate intake of vitamin A through a balanced diet could be approximately 1078.71 to 1173.96 mcg RE without fortification. Fortified foods add an additional 418.5 mcg of vitamin A in a day taking the intake around 1496.51 to 1592.46 mcg RE after consuming fortified foods. Tolerable upper limit is 900 mcg RE /day.
Vitamin D:

Children 1-3 years: The intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 25.285 to 27.165 mcg/day. Fortification provides an additional intake of 6.5 mcg/day. However, this is based on the assumption that children in this age group consume the balanced proportions of all food groups as suggested by ICMR. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. Hence the intake would provide only 11.22 mcg/day. The TUL for Vitamin D for children aged 1-3 years is 62.5 mcg/day.

Children 4-6 years: The intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 26.11 to 36.03 mcg/day. Fortification provides an additional intake of 6.5 mcg/day. The TUL for vitamin D is 75 mcg/day. However, this is based on the assumption that children in this age group consume the balanced proportions of all food groups as suggested by ICMR. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. Hence the intake would provide only 14.17 mcg/day which it is within safe limits.

Children 7-9 years: The intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 43.09 to 46.85 mcg/day. Fortification provides an additional intake of 7.175 mcg/day. The TUL for vitamin D is 100 mcg/day. However, this is based on the assumption that children in this age group consume the balanced proportions of all food groups as suggested by ICMR. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. Hence the intake would provide only 18 mcg/day which it is within safe limits. (Refer Figure 37).
Iron:

As observed in Figure 38, Iron intake via a balanced meal could be approximately 5.957 to 6.422 mg/day in children aged between 1-3 years. The intake of iron has been calculated keeping in mind the richest sources of iron and this indicates the maximum children in this age group could consume via diet. However, the actual intake is much lower and is not 100% bioavailable, thereby not able to meet the RDA. This justifies the fortification which adds about 3.012 mg of iron in a day. TUL for iron for children aged 1-3 years is 40mg/day where the intake would be well within the safe limits.

Iron intake via a balanced meal could be approximately 5.479 – 8.384 mg/day in children between 4-6 years. However, the actual intake is much lower and is not able to meet the RDA (11mg/d). This justifies the intake of fortified staples which adds about 5.052 mg of iron in a day. The TUL for iron is 40 mg/day.

Iron intake via a balanced meal could be approximately 12.326 – 13.256 mg/day in children between 7-9 years. However, the actual intake is much lower and is not able to meet RDA (15mg/d). This justifies the fortification which adds about 8.05 mg of iron in a day. The TUL for iron is 40mg/day.
Total Folates (Folic Acid):

Children 1-3 years: Folic acid is obtained mainly from vegetarian sources and if a balanced diet is consumed, one can have an intake of 217.32 – 243.39 mcg/day. Fortification provides an additional 6 mcg/day. TUL values for Folic acid are not available for children aged 1-3 years. (Refer Figure 39)

Children 4-6 years: Folic acid is obtained mainly from vegetarian sources and if a balanced diet is consumed, one can have an intake of 258.88 – 284.95 mcg/day. Fortification provides an additional 12 mcg/day. TUL values for Folic acid are not available for children of this age group.

Children 7-9 years: Folic acid is obtained mainly from vegetarian sources and if a balanced diet is consumed, one can have an intake of 415.49 – 363.29 mcg/day. Fortification provides an additional 18 mcg/day. TUL of folates is 300 mcg/day.
Vitamin B12:

Dietary vitamin B12 values have been obtained from the Nutritive Value of Indian Foods (1989) as the new IFCT (2017) does not include these values. However, Vitamin B 12 values of only 2 food sources i.e milk and egg have been included in these. As per these 2 values the intake would range from 0.7 to 1.6 mcg/day. Fortification adds another 0.06 mcg/day in 1-3 years old; 0.12 mcg/day in 4-6-year old and 0.18 mcg/day in 7-9 year old. The TUL values of vitamin B 12 are not available but assuming this is a water soluble vitamin, toxicity levels would be quite high. (Refer Figure 40).
2.5 GIRLS (10-12 YEARS, 13-15 YEARS, 16-18 YEARS)

There is a difference in girls and boys now. Particularly in iron requirement why? Adolescence is the period of transition from childhood to adulthood and a period of rapid growth and maturity both physiologically and psychologically. Nutritional needs vary during adolescence. They are different for males and females. This is mainly due to differences in growth spurts and sexual maturation. Puberty hits females between the age group 10-14, whereas for males it occurs between 12-16 years of age. Differences are seen not just in caloric and macronutrient requirements, but also in the requirements of micronutrients. Iron requirements are generally higher in females due to increased physiological demands and menstrual losses.
Vitamin A:

Girls 10-12 years: The approximate intake of vitamin A through a balanced diet could be approximately 1138.14 - 1234.05 mcg RE without fortification. Fortified foods add an additional 458.25 mcg of vitamin A in a day taking the intake around 1596.39 to 1692.3 mcg RE after consuming fortified foods.

Girls 13-15 years: The approximate intake of vitamin A through a balanced diet could be approximately 1138.27 - 1234.18 mcg RE without fortification. Fortified foods add an additional 498 mcg of vitamin A in a day taking the intake around 1636.27 - 1732.18 mcg RE after consuming fortified foods.

Girls 16-18 years: The approximate intake of vitamin A through a balanced diet could be approximately 1314.31 - 1410.22 mcg RE without fortification. Fortified foods add an additional 458.25 mcg of vitamin A in a day taking the intake around 1772.56 - 1868.47 mcg RE after consuming fortified foods.

As observed in Figure 41 even after this additional amount the total intake is much below the tolerable upper limit of 2800 mcg RE /day.
Vitamin D:

Girls 10-12 years: The intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 56.1 – 59.86 mcg/day. Fortification provides an additional intake of 7.85 mcg/day. The TUL for vitamin D is 100 mcg/day. However, this is based on the assumption that girls in this age group consume the balanced proportions of all food groups as suggested by ICMR. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. Hence the intake would provide only 22.57 mcg/day which it is within safe limits.

Girls 13-15 years: The intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 62.13 – 65.89 mcg/day. Fortification provides an additional intake of 8.525 mcg/day. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. Hence the intake would provide only 24.8 mcg/day which it is within safe limits.

Girls 16-18 years: The intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 64.92 – 68.68 mcg/day. Fortification provides an additional intake of 7.85 mcg/day. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. Hence the intake would provide only 25.51 mcg/day which is within safe limits (Refer Figure 42).
Iron:

Iron intake via a balanced meal could be approximately 14.258 – 15.188 mg/day in 10-12 years girls; 16.42 – 17.356 mg/day in 13-15 years girls and 17.926 – 18.856 mg/day in 16-18 years girls. The intake of iron has been calculated keeping in mind the richest sources of iron and this indicates the maximum girls in this age group could consume via diet. However, the actual intake is much lower and is not able to meet the demand. This justifies the fortification which adds about 9.13 mg in 10-12 years old; 10.71 mg in 13-18 years girls of iron in a day. The TUL for iron is 45 mg/day as observed Figure 43.
Folic Acid:

Girls 10-12 years: Folic acid is obtained mainly from vegetarian sources and if a balanced diet is consumed, one can have an intake of 414.85 – 467.05 mcg/day. Fortification provides an additional 24 mcg/day and this is well within the safe TUL of 600-800 mcg/day.

Folic acid is obtained from a balanced diet is 432.19 – 484.39 mcg/day in 13-15 years old and 490.59 – 542.79 mcg/day in 16-18 years old. Fortification provides an additional 33 mcg/day and this is well within the safe TUL as observed in Figure 44.

Vitamin B12:

Dietary vitamin B12 values have been obtained from the Nutritive Value of Indian Foods (1989) as the new IFCT (2017) does not include these values. However, Vitamin B12 values of only 2 food sources i.e milk and egg have been included in these. As per these 2 values the intake would range from 0.7 to 1.6 mcg/day. Fortification adds another 0.24 mcg/day in 10-12 years old; 0.33 mcg/day in 13-15 years old and 16-18 years old. The TUL values of vitamin B12 are not available but assuming this is a water soluble vitamin, toxicity levels would be quite high. (refer Figure 45).
It is most important to meet the nutritional needs during adolescence to ensure a healthy adulthood along with fostering healthy food habits. As discussed earlier there is a many influence on eating habits during adolescence. Breakfast is frequently neglected more often by teenagers. They are most vulnerable to the food advertisements which lead to consumption of food rich in energy, fat and sugar but may lack other essential micronutrients. Thus consumption of fortified staples is essential for adolescent boys as well.
Vitamin A:

Boys 10-12 years: The approximate intake of vitamin A through a balanced diet could be approximately 1234.14 – 1243.53 mcg RE without fortification. Fortified foods add an additional 458.25 mcg RE of vitamin A in a day taking the intake around 1629.78 – 1692.39 mcg RE after consuming fortified foods.

Boys 13-15 years: The approximate intake of vitamin A through a balanced diet could be approximately 1227.19 - 1323.1 mcg RE without fortification. Fortified foods add an additional 537.75 mcg of vitamin A in a day taking the intake around 1764.94 – 1860.85 mcg RE after consuming fortified foods.

Boys 16-18 years: The approximate intake of vitamin A through a balanced diet could be approximately 1228.71 – 1324.62 mcg RE without fortification. Fortified foods add an additional 577.5 mcg of vitamin A in a day taking the intake around 1806.21 – 1902.12 mcg RE after consuming fortified foods.

As observed in Figure 46 even after this additional amount the total intake is much below the tolerable upper limit of 2800 mcg RE /day.
Vitamin D:

Boy 10-12 years old: The intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 60.16 – 68.08 mcg/day. Fortification provides an additional intake of 7.85 mcg/day. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. The TUL for vitamin D is 100mcg/day. However, this is based on the assumption that boys in this age group consume the balanced proportions of all food groups as suggested by ICMR. Hence the intake would provide only 22.67 - 25.31 mcg/day which it is within safe limits.

Boy 13-15 years old: The intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 70.6 – 74.36 mcg/day. Fortification provides an additional intake of 9.2 mcg/day. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. Hence the intake would provide only 26.6 – 27.9 mcg/day which it is within safe limits.

Boy 16-18 years old: The intake of vitamin D in the form of Cholecalciferol and ergocalciferol is estimated to be around 71.4 – 75.43 mcg/day. Fortification provides an additional intake of 8.65 mcg/day. Only a third of the dietary ergocalciferol gets converted to vitamin D3 in the body. Hence the intake would provide only 26.7 - 28 mcg/day which it is within safe limits.(refer Figure 47).
Iron:

Boy 10-12 years old: Iron intake via a balanced meal could be approximately 15.92 – 18.46 mg/day. The intake of iron has been calculated keeping in mind the richest sources of iron and this indicates the maximum boys in this age group could consume via diet. However, the actual intake is much lower and is not able to meet the demand. This justifies the fortification which adds about 10.19 mg of iron in a day.

Boy 13-15 years old: Iron intake via a balanced meal could be approximately 19.76 – 20.69 mg/day. This justifies the fortification which adds about 12.31 mg of iron in a day.

Boy 16-18 years old: Iron intake via a balanced meal could be approximately 20.21 – 21.14 mg/day. This justifies the fortification which adds about 11.93 mg of iron in a day. The TUL for iron is 45 mg/day as observed in Figure 48.
Total Folates (Folic Acid):

Boy 10-12 years old: Folic acid is obtained mainly from vegetarian sources and if a balanced diet is consumed, one can have an intake of 508.44 – 426.41 mcg/day. Fortification provides an additional 30 mcg/day and this is well within the safe TUL of 600-800 mcg/day. (Refer Figure 49)

Folic acid obtained from a balanced diet is 497.43 – 550.13 mcg/day in 13-15 years old; 532.51 – 584.65 mcg/day in 16-18 years old. Fortification provides an additional 42 mcg/day and 40 mcg/day in 13-15 years old and 16-18 years old respectively and this is well within the safe TUL.

Vitamin B12:

Dietary vitamin B12 values have been obtained from the Nutritive Value of Indian Foods (1989) as the new IFCT (2017) does not include these values. However, Vitamin B 12 values of only 2 food sources i.e milk and egg have been included in these. As per these 2 values the intake would range from 0.7 to 1.6 mcg/day. Fortification adds another 0.3 mcg/day in 10-12 years old; 0.42 mcg/day in 13-15 years old and 0.40 mcg/day in 16-18 years old. The TUL values of vitamin B 12 are not available but assuming this is a water soluble vitamin, toxicity levels would be quite high. (Figure 50).
CONCLUSION
Nutrition is a basic human need and a prerequisite to healthy life. India is in a constant state of struggle to end hunger, under nutrition and micronutrient malnutrition at one end to lower the risks of lifestyle related disorders (NCDs) like obesity and cardiovascular diseases.

Diets at times are deficient in quantity and quality due to several reasons like lack of knowledge, financial constraints, lack of availability of foods or other environmental constraints. The disparity in diet quality is more evident for the most vulnerable groups like women and children. It is also possible that the bioavailability of these nutrients from the indigenous amounts of nutrients is low due to the type of food consumed (heme vs non-heme iron) or due to the presence of certain inhibitors of absorption of a particular nutrient (e.g. phytates for iron absorption). All these result in an insufficient intake of certain micronutrients via the diet.

Food fortification is a low cost, scalable, scientifically proven and sustainable intervention to address micronutrient malnutrition and “not a replacement of balanced, diversified diets”. Fortification only bridges the gap between the need and actual consumption of required micronutrients through food. Dietary diversification, supplementation and food fortification are not “Either / Or” choices but “Complementary Strategies”.

Adverse functional outcomes like stunting, increased susceptibility to infectious diseases, physical impairments, cognitive losses, blindness and premature mortality are also caused by deficiencies of various micronutrients as well. On the request of various line ministries, FSSAI notified the Regulations in 2018 and the +F logo for identification of fortified staples. The dosages of nutrients added to the staples is adjusted to provide 30-50 percent of an individuals’ daily nutrient requirement. Food Fortification can help provide access to these micronutrients. The uptake of fortified foods is better as there are no organoleptic changes. This will ensure that the coverage is optimum.

As part of the fortification strategy, all the Government Safety Net programmes namely Integrated Child Development Services (ICDS), Mid-Day Meal (MDM) and Public Distribution System (PDS) are covered to include the fortified staples in services that are provided to the beneficiaries under each scheme. A lot of states have now started implementing fortification across their safety net programmes.

The document was created to highlight the intake of 6 specific nutrients via fortified and non-fortified foods. It was observed that in some cases the nutrient intake could be achieved by non-fortified staple diet as well, however, it is important to keep in mind that this under the ideal situations when individuals are consuming well balanced diets which provide foods from all food groups in adequate amounts. But, the actual situation is far from this ideal scenario.

Since the level of fortification in each of these fortified staples is adjusted in such a manner that intake of any particular nutrient does not cross the TUL on a daily basis, it can be said that fortification is a safe method to provide nutrients to individuals in a population at a very nominal additional cost.
In order to address any concerns towards fortification, using the lifecycle approach and the comparison between fortified v/s non-fortified staples, it can be concluded that the current drive on fortification addresses a critical public health concern. With such high levels of micronutrient malnutrition, food fortification offers a very cost-effective solution as a supplementary intervention. Fortification technology is easy and indigenous and does not require huge investments.

Thus, to meet the RDA, adequate quantity and quality micronutrient are required which can be achieved by consuming fortified staples. These fortified staples can provide that window of opportunity which would help in promoting suitable intake of certain micronutrients which are deficient in the diets of many Indians.
REFERENCES


• Report of expert committee. To examine allowances of vitamins/minerals more than
one RDA in healthy/dietary supplements and nutraceuticals and safe upper limits. ICMR, 2018.


Table 2: The quantity of food groups consumed during a day through the lifecycle

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<td>30 (oilseed)</td>
<td>15</td>
<td>15</td>
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<td>30 (oilseed)</td>
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</table>

(Reference- Dietary Guidelines, NIN, 2010; *Dietary Guidelines, NIN, 2020)