REVIEW OF LITERATURE

CHAPTER 2

REVIEW OF LITERATURE

The Literature was collected on the following topics, for the present research:

2.1 Micronutrient Deficiency

2. 1.1 Global Prevalence of Micronutrient Deficiency

India currently has 195.9 million undernourished people, leading to alarming issues of food insecurity. (World Food Program., 2019). According to a recent Global Hunger Index report published in 2019, India ranks 102 out of 117 countries (von Grebmer et al., 2019). Micronutrients are defined as the 'Compounds required in very smaller amounts, <100mg/dl). It includes vitamins and minerals that are required in small quantities but holds a very important role in our body. They are vital for carrying out the various functions in our body, in managing growth, and production of hormones as defined by the World Health Organization. Micronutrient deficiency is also called 'Hidden Hunger' which is described as the habitual diet which lacks the essential micronutrients at necessary levels or cereal-based diets lacking other food groups thus impacting the health of the individual in the long run, which might not be acutely visible. Micronutrient deficiency complications result in early death, impoverished health, stunted growth, etc. WHO has reported deaths of under-five children due to undernutrition by 45%, iron deficiency by 42% in children, and 40% amongst pregnant women (Venkatesh et al., 2021).

Malnutrition starts early, right from the inception of Pregnancy. One of the forms of malnutrition is Micronutrient Deficiency which is a Global issue. Worldwide 2 billion people are facing Micronutrient deficiency and out of it, 1 billion people are from India. (FSSAI., 2018a), Micronutrients are required in tiny amounts but hold a very important role in one's diet for healthy growth and development. Nearly 50-60% of the preschool children and an equal number of women in India are anemic (Gonmei and Toteja., 2018), 62% of the Indian Population have low levels of Vitamin A and 50-94% of people in different states of India are suffering from Vitamin D deficiency (Gulati., 2018b). According to (NFHS 4., 2017), micronutrient deficiency is prevalent in all age groups. (Refer: Figure 1) Thus to combat micronutrient deficiency, WHO has recognized Fortification as a bridge in filling the micronutrient gaps which is an affordable and viable approach. According to the FSSAI report, all the food business operators must comply with Fortification regulations by January 1st, 2019 (FSSAI., 2018a).

At present, there are 157 Fortified brands available in the open market across the country (Teaotia and Singhal., 2020). Specifically stating, there are 80 brands of Fortified edible oils, 55 for Milk, 12 for Wheat flour, 2 for rice, and 8 brands of double Fortified salt (FSSAI., 2020).

According to Micronutrient Forum, 2020 (Osendarp and Kraemer., 2020), approximately 3 billion people are lacking access to basic nutrients in their diets throughout the year. Post pandemic, an additional 4.8 million mothers are prone to be impacted by anemia due to affected availability and affordability during Covid. Poor diets among the population are the main challenge resulting in micronutrient deficiency, which has also led to societal challenges and economical burdens since it leads to the cause of morbidity and mortality, especially in infants and pregnant women. In the year 2017, WHO and UNICEF have conducted a worldwide assessment and reckoned that 34% of households did not have access to iodized salts, and approximately 190 million children and pregnant women are deficient in Vitamin A and other micronutrients.

In India, National Family Health Survey 4 – has recorded the highest burden of anemia worldwide, 58.6% in children and 53.2% in non-pregnant women, and 50.4% in pregnant women in 2016. The National indicators (NFHS 5., 2022) has recorded an increase in anemia in women of all age group to 57% from 53% in NFHS 4, children (6-59 months) by 67% from 58% in NFHS 4. Gujarat has recorded 80% of anemia prevalence in children between the age group of 6-59 months, however, Bihar has recorded the highest anemia prevalence amongst pregnant women at 63%.

According to a recent National report (2016-18) conducted by the Ministry of Health and Family Welfare (*CNNS Report.*, 2019), the prevalence of deficiency in various vitamins is: 16% vitamin A deficiency among adolescents, 24% vitamin D, 32% Zinc, 31% Vitamin B12 and 37% folate deficiency CNNS report also provides insights into the dietary habits of adolescents 10-19 years old, it states that the Consumption of Fruits and eggs is less than 10% for boys and girls. Over 25% of adolescents reported no consumption of green leafy vegetables even once a week. Milk products are consumed by only 50% percent of adolescents daily Nearly 25% of girls and boys do not receive any of the four school-based services (mid-day meal, biannual health check-ups, biannual deworming, and weekly iron-folic acid supplementation) Prevalence of zinc deficiency in Gujarat is 55% and vitamin B 12 is 48%.

The report reveals a spike in poverty levels, and food prices, affecting the consumption pattern of cereals and cereal substitutes which fell by 20.4% in rural India and by 7.9% in urban India. The fall in total food consumption expenditure was 9.8% for rural India while it increased marginally by 0.2% for its urban counterparts.

The comprehensive National Nutrition Survey of Children (CNNS) has been conducted in partnership with UNICEF, to assess the burden of malnutrition in children and adolescents. Prevalence of zinc deficiency was recorded by 19% in pre-school children, and 32% in adolescents.

Multiple efforts have been taken up by the Government of India by launching various programs and schemes to address micronutrient malnutrition.

The prevalence of undernutrition according to NNMB, among infant boys was 29% for underweight, and 23% for stunting and wasting by 25%. Karnataka, Andhra Pradesh, Gujarat, Madhya Pradesh, Orissa, and Uttar Pradesh were a few states which recorded the highest prevalence of stunting. The report records a decline in household intake of cereals and millets and marginal improvement in uptake of leafy vegetables. The anthropometry recorded better nutrition status however the possible cause of which could be accessibility to health care facilities, sanitation, etc. (NIN., 2012).

The existence of micronutrient deficiency and its association with undernutrition with diet-related diseases has been categorized as a Double Burden of Malnutrition. Various micronutrient deficiency leads to stunting, and wasting since the growth of the child gets hampered. In 2016, 41 million children under the age of five, were under the category of overweight, whereas 155 million suffered from low height for age during the same time (WHO., 2017).

2.1.2 Studies on Micronutrient Deficiency across the World

There are 19 types of micronutrients needed to maintain a healthy human body. (Fig 2.1) Though micronutrients are required in less quantity their function is huge. Lack of micronutrients cause impaired poor physical and mental health. Today, two billion people are suffering from micronutrient deficiency which is also known as hidden hunger since it rarely shows any visible sign in an individual. The burden of deficiency accounts for 10% of the global health issues. Major health complications caused due to lack of micronutrients include

Goiter, Spina Bifida, Nigh Blindness, reduced work productivity, and affected concentration (GAIN., 2015)

Figure 2.1 Functions of Various Micronutrients

Micronutrient holds important functions in the body throughout the life span of an individual. If left untreated during the in utero stage it may extend and affect the other stages of life from childhood to adolescence to pregnant women and old age. Apart from affecting the stages of

life it also affects the generations since it starts before the stage of conception creating developmental delays and deficits. The 4th report on The World Nutrition shared the conceptual framework of micronutrient deficiency across the lifespan (Kweba., 2019) (WNS., 2000)

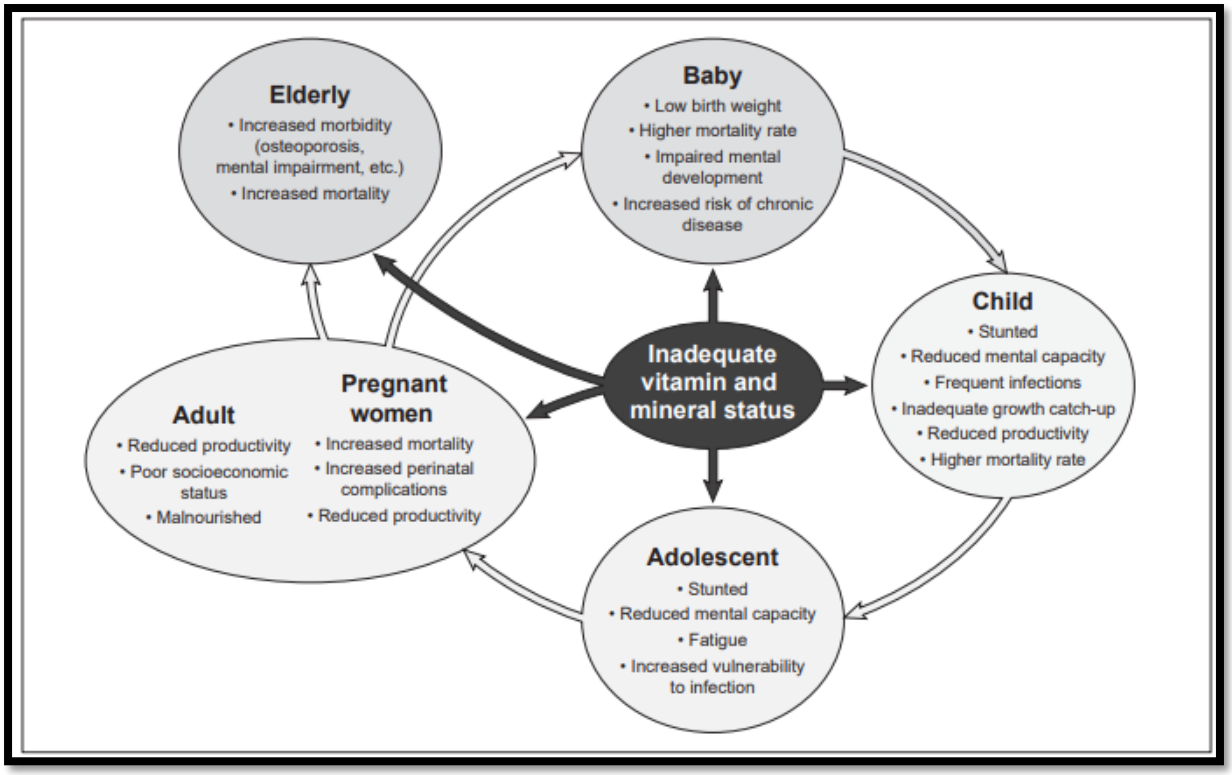


Figure 2.2 Micronutrient Deficiency throughout the lifespan

Micronutrient deficiency has been studied worldwide and it has been found that the majority of the population in different countries is suffering from micronutrient deficiency and food has been given importance in context to calorie requirements and not micronutrients that are equally important for a diet (Kimenju et al., 2015).

In Kenya, 33% of women and nearly 7% of children are experiencing vitamin A deficiency because of which 30% of children are suffering from eye infections while others are encountered infectious diseases as an outcome of vitamin A Deficiency.

Vitamin A is considered an important micronutrient as its deficiency can lead to a weak immune system which makes an individual prone to infectious diseases which at times can be fatal. Vitamin A deficiency (VAD) has been seen in every age group and country, giving rise to mortality rates It has been seen that around 60,000 women every year due to VAD. Plant-based foods have less bioavailability of Vitamin A as compared to animal sources, which are a good source of retinol, In India, animal-based foods are consumed by the minority, thus

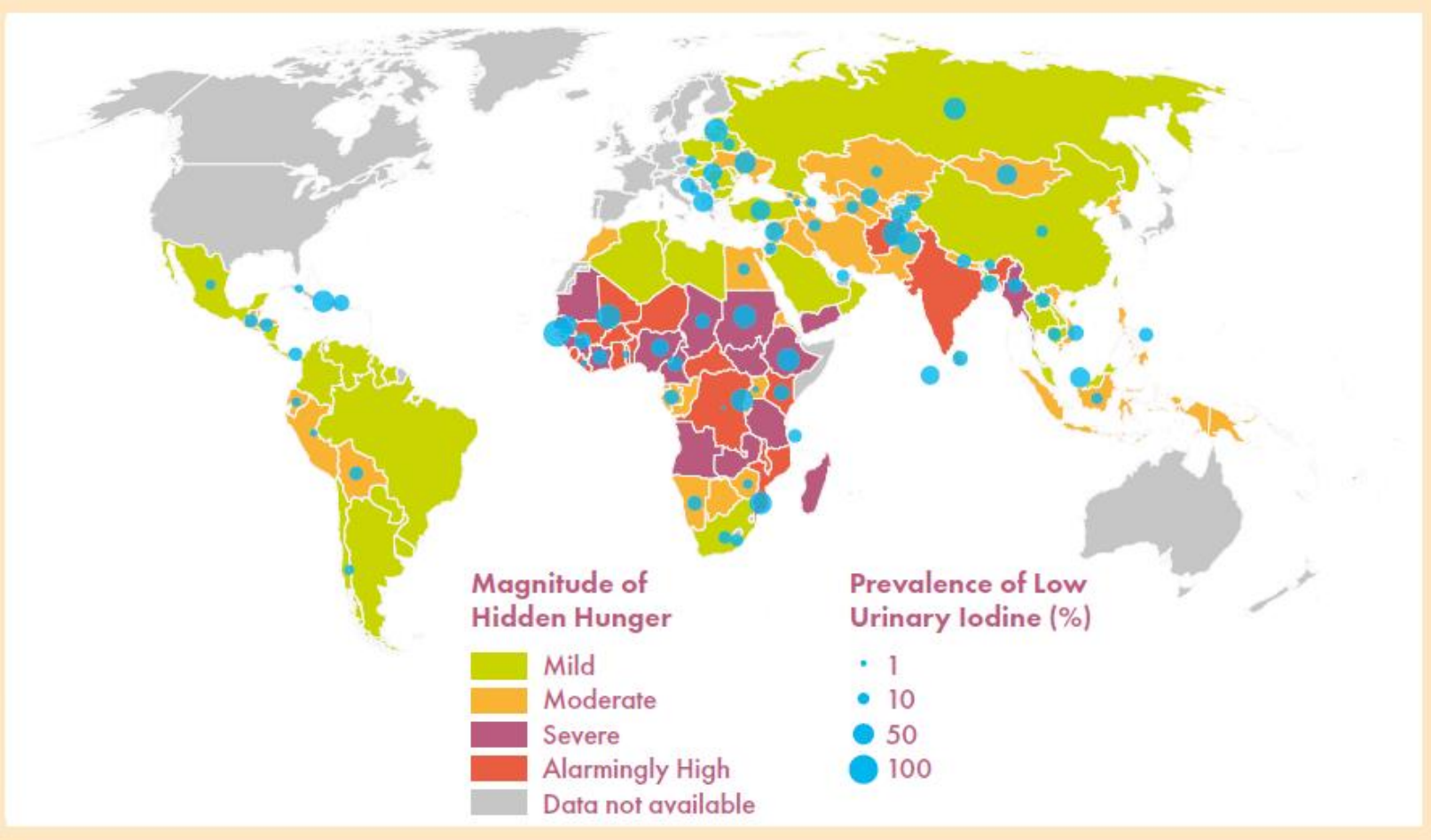
making it evident to Fortify major staples with Vitamin A, to reach people of every community and strata.

Kenya has high rates of deficiency, nearly 70% of children and women around 33% are suffering from VAD, and animal-based sources rich in Vitamin A are limited thus Fortifying sugar with Vitamin A was a much-needed step in Kenya (Pambo et al., 2014a).

A study was conducted in South Africa on 260 women (Age 19-69 years) of Gauteng Province where dietary diversity was assessed using 24-hour dietary recall, the study revealed that women 36 years and older were at risk of micronutrient deficiency, especially for Vitamin A, calcium and Vitamin C (Acham et al., 2012a).

Malnutrition is a major problem in Vietnam despite a decrease in poverty rates from 37.4% in 1998 to 13.4% in 2008. Iron deficiency has been a major problem amongst pregnant women for which Fortification has been considered the safe and most cost-effective strategy to combat the situation since it does not require a change in food habits. The staple items consumed in Vietnam are soya, fish sauce, condiments, spice powders, and edible oils. According to National Nutrition Survey conducted in Vietnam recorded the prevalence of anemia amongst children by 9.1%Iron deficiency of which iron deficiency is 12.9% and zinc deficiency amongst 51.9%, Vitamin A by 14.2% leading to malnutrition of more than one micronutrient (Turk and Spohrer., 2016).

India, following a predominantly vegetarian diet, has a limited intake of animal and animal-based food products which are rich in Vitamin D, Vitamin B12, Vitamin A, Iron, etc., thereby negating the benefits of these food sources and worsening the deficiency amongst the people. The change in lifestyle in rural and urban settings has limited the exposure of the people to sunlight which is a natural source of Vitamin D and plays a crucial role in preventing issues like osteoporosis, rickets, diabetes, cardiovascular diseases, Immunity, etc. Vitamin D is a natural source that is photosynthesized in the skin through UVB rays exposure, but the alarming prevalence rates in India despite plentiful sunshine is worrisome. Vitamin D Deficiency often goes unnoticed and unaddressed even if the Indian staple diet is adequate since the diet lacks the sources of Vitamin D (Ritu and Gupta., 2014).



Source: *https://www.plantagbiosciences.org/people/nyamisi-kweba/2019/05/22/why-Fortify-foods/*

Figure 2.3: Magnitude of Hidden Hunger Around the World (Kweba., 2019)

A review paper on Vitamin A deficiency has recorded scientific data which reveals the severity of Vitamin A in various states of India. A survey conducted in Maharashtra assessed the prevalence to be 9.8% amongst the children aged between 5-15 years of age. Similarly, another study conducted in Jodhpur amongst 5135 students has recorded similar results. (Shaikh., 2018). A study was conducted in Ahmedabad amongst preschool children (5-15 years) to find out the prevalence of Vitamin A deficiency (VAD). The study finds out prevalence amongst girls by 4.1% and 1.9% in boys which was significantly higher in girls. The researcher also observes that there is insufficient consumption of green leafy vegetables, and fruits amongst these children, which could be the cause of VAD. Efforts should be made for strict policy by which deficiencies can be addressed on large scale (Chauhan et al., 2011).

2.2 Strategies adopted for overcoming the Micronutrient Deficiency

Micronutrient Deficiency is the burning issue that has disturbed and increased the complexity of the world. The recent trend has observed the transition from traditional home-based diets to processed foods, and junk food which has further diminished the micronutrient intake, since these foods are only calorie dense, leading to obesity and diet-related Non Communicable diseases, further leading to a triple burden of malnutrition. The triple burden consists of undernutrition wherein people do not receive an adequate amount of macro and micronutrients, obesity where there is an excess of calorie intake, and micronutrient deficiency which means the body lacks the essential micronutrients required by the body in tiny amounts (Pinstrup-Anderson., 2006). Multiple surveys have been undertaken by WHO and other renowned organizations for the ways that can be adopted to combat the micronutrient deficiency and are at the same time cost-effective.

2.2.2 Dietary Diversity

Dietary Diversification is the form of changing the food habits of the people by promoting the intake of more food groups in the diet at the household level and having a diversity such as animal-based food products and leafy vegetables in the daily diet. The aim of changing the diets of the people is to have more food groups that will supply different micronutrients to the body in adequate proportions (USAID, n.d.). Getting all the essential micronutrients from only selected food groups is not a plausible strategy, especially in India which is predominantly vegetarian in nature, and lacks the essential micronutrients like Vitamin D, Vitamin B 12, and

Iron, also because the major part of the Indian diet is cereal based in nature owning to the sheer intake of cereals. Dietary Diversification, however, cannot be scaled up for overcoming the deficiency of micronutrients, since it lacks the evidence and the monitoring of the diets people of the community are having on a daily basis, it is difficult to ensure whether the people are having adequate food groups in their daily diet just by educating them once. Also, dietary diversity is a challenge for countries or people having limited income sources, since having a diet rich in various food groups, puts a lot of pressure on the pocket of the individual, which further hampers the affordability of the fruits and vegetables. To call dietary diversification a successful strategy for overcoming micronutrient deficiency will take a lot of effort and advocacy sessions since breaking the inertia of developed habits is quite a challenge. The strategy will need a lot of time to be absorbed by the people by having extensive self-monitoring of their diets (Nair et al., 2016).

2.2.2 Supplementation Programs

Multiple programs have been running in India to combat the micronutrient deficiency rates which need immediate attention due to its ever-increasing prevalence in the states due to changes in food habits and preferences towards processed foods. Food supplementation through various programs like Mid-Day Meals is the largest program active in government schools that provides lunch to the students and is currently reaching 104.4 million children in approximately 1.2 million schools across Indian states (C. Mirajkar and Ravindra., 2016). The program was started to increase the rate of attendance of the children in schools and to provide a meal to ease the pressure of the families to meet the need for two square meals for their children. The program has observed a reduced number of absentees, however, it cannot be scaled up as a strategy for addressing micronutrient deficiency, since its targets only one sector of the socioeconomic group and particular age group. Micronutrient deficiency is not observed only amongst the poor section of the society, thus need was felt to adopt different strategies which could address all at once and is cost effective.

Another program- Integrated Child Development Scheme (ICDS) has packages for children, pregnant women, and lactating women wherein supplementary food packed or in meals is provided to beneficiaries (Sachdev and Dasgupta., 2001).

Other Programmes include the provision of iron folic acid tablets to women and children, under Weekly Iron Folic Acid Supplementation (WIFS), Vitamin A prophylaxis program, Iodine Deficiency Disorder Programme, Poshan Abhiyan which has recently launched in 2018, 8th March intending to improve the nutritional status of the people.

All these supplementation programs need a long-term commitment and require constant supervision at regular intervals by the team of government and private stakeholders. The major limitation in the program observed was it needs too many human resources to keep a check on monitoring and evaluation of the program at different states at different levels and was high on cost. Such programs were not targeting the population at large of all socioeconomic groups.

Thus Food Fortification was considered the best and most viable strategy to overcome micronutrient deficiency rates since it has the potential to address many concerns all at once (Pritwani and Mathur., 2015).

2.2.3 Food Fortification

Food Fortification is the enrichment of the food with essential micronutrients for improving its nutritional content and improving the deficiency rates amongst the population. Food Fortification is usually done in food items that are commonly consumed by people and are a part of their daily diets. Premixes are added to staple foods like wheat flour, rice, salt, milk, and oil for restoring the micronutrients in them which are either not present or lost due to manufacturing processing. Food Fortification is considered cost-effective since it is done on a massive scale and targets people of every socioeconomic scale (Lovedeep et al., 2018).

Food Fortification is an upcoming area of interest for researchers, public health nutritionists, and other health professionals. Food Fortification is seen as one of the effective methods to tackle micronutrient deficiencies amongst the general population by Fortifying the staples that are being eaten in significant quantities by almost everyone and is a part of their daily diets. But this strategy is not as simple as it seems, because a lot of work is required to educate the population about its benefits and the need, without which the aim of having less prevalence of hidden hunger will not be achieved.

Micronutrient deficiency is associated with factors like consumption of animal products that are rich in vitamin B12, poor bioavailability of certain micronutrients, and lack of hygiene practices that again affect bioavailability and digestion process, lack of food availability, lack

of awareness amongst the population which affects their dietary diversity (Murphy and Allen., 2003).

2.2.3.1 Fortification as a Promising Strategy and Choice of Vehicles

According to one of the studies conducted in Bangladesh amongst children between 2-4 years and women had non-lactating women, it has been observed that 44% of children and 30% of non-lactating only had adequate micronutrient intake for which the source was starchy staples, thus it becomes really important to choose a vehicle which is consumed in large quantities in every country to efficiently target micronutrient deficiency (Arsenault et al., 2013).

The micronutrient deficiency is the emerging public health issues in many developing countries. The adequate micronutrient intake is considered as crucial especially during the first 1000 days of life. A systematic review and meta-analysis study found that iron multi micronutrient fortification leads to increase in the haemoglobin level by 0.87g/dl and reduces the risk of anemia by 57% when compared to the non-fortified food (Eichler et al., 2012).

Another study conducted in Bangladesh on preschool children tried to find out the percent RDA of micronutrient deficiencies amongst children and the result showed that for iron it was 23.7%, zinc (28%) Vitamin A (50%) folic acid (26%) and vitamin B12 intake (62%). Consumption of Fortified Foods amongst Non-pregnant and non-lactating women in Bangladesh was 100% for Fortified rice, Fortified bread (10%) Fortified wheat flour (41%), and sugar (30%). As Rice is consumed in high quantity and is a part of their staple diet, it has been said that if rice is being Fortified with Iron, it will serve 40-80% of RDI values of iron, which is 13-20mg of iron/per day which will further help in overcoming iron deficiency, whereas 7.5- 17.5 mg of zinc/day can be provided following rice Fortification. According to the results of the study, it has been concluded that wheat flour and rice Fortification alone can help in overcoming micronutrient deficiency of iron, vitamin B12, zinc, and folic acid to certain limits as they are the part of staple diets for the majority (Leyvraz et al., 2016).

There are two types of Fortification strategies, voluntary and mandatory Fortification. The Netherlands follows voluntary Fortification of foods with micronutrients within a range of 15% to 100% of the reference intake. A study was conducted by Jong et al, 2021. Using the food consumption survey data amongst the Dutch Population with the aim to study the consumption

of Fortified Foods amongst the adults aged 16-70 years. A total of 75% of the population were consuming Fortified beverages, oils and fats, and dairy products, contributing to micronutrient intakes by 9%- 78%. The study recorded the impact of voluntarily Fortified Foods on the micronutrient intake amongst the users. Since the regulations were not mandatory in the country, voluntary Fortification led to the Fortification of meat, alcohol, and other items which were also contributing to higher fat, sugar, and salt intake, thus raising a question regarding healthy choices according to the wheel of five which is a nutrition guide of the Dutch population (De Jong et al., 2022).

A study was conducted on infants aged 6-12 months to understand the impact of the fortified porridge on the improvement status of anemia and motor development. The study concludes that those infants who were provided with the fortified porridge, the proportion decreased from 45% to 17% compared to the control group (>40%). Also, the scoring of 25 motor development found improved (15.5) than the control group (14.4) (Faber et al., 2005).

Fortification of refined vegetable oil and wheat flour is a mandate in Cameroon since 2011 with Vitamin A and iron, zinc, Vitamin B12, and folic acid respectively. A study was conducted to identify the barriers to food Fortification by conducting interviews of the factory owners (n-19) and the consumers for recording their consumption levels (n=613 households). The researcher collected samples of Fortified Foods from factories, households, and open markets using purposive sampling. The study recorded low levels of micronutrients added to the products in the samples of factories needing consistent monitoring to Fortify the staples as per the regulations of the country. Reach of Fortified oil was higher amongst the women whereas wheat flour consumption was high amongst the children. Fortifiable" oil was consumed by 63% of women and 52% of children during the previous week of the survey and wheat flour by 82% of women and 86% of children. The micronutrient analysis for wheat flour and oil showed differences amongst the samples collected from factories, markets, and households (Mark et al., 2019).

A study was conducted among school aged children (6-15 years) on whole wheat flour reduces the iron deficiency and improves body Fe stores along with cognitive performance. With the intervention for 7 months, the prevalence of iron deficiency anemia significantly reduced from 18% to 9%. The body Fe stores increased (0.04 ± 0.04 mmol/kg body weight) among the intervention group of the children, however, it decreased (-0.02 ± 0.04 mmol/kg body

weight) among control group (Muthayya et al., 2012). A similar study was conducted where Multi-micronutrient food fortification tends to improve micronutrient status and consequently reduce anemia prevalence (Best et al., 2011).

Different countries and reports have calculated the cost-effectiveness of Fortification as a strategy to be effective in reducing the micronutrient deficiency. Every single dollar invested for Fortification will provide 16 times of return in the total economy of the nation. Uganda, on the other hand, has an estimated lack of productivity due to micronutrient deficiency which has affected the nation's GDP by 14% (Kistner., 2017).

In 2010 research was conducted on scaling up nutrition by WHO which calculated a return of US$ 7.2 billion in a year similarly in Jordan the cost of treatment and the cost of Fortification for anemia were compared. It was calculated that the Fortification process would cost 0.03 dinars (approx. US$0.04) per capita per year, whereas the treatment of the anemic population will cost 4.9 dinars (approx. US$7.00) (GAIN., 2015).

2.2.3.2 Consumer Awareness for Fortified Foods

Fortification is one of the strategies to overcome micronutrient deficiency which has been taken up by many countries other than India namely, the USA, Kenya, Bangladesh, etc.

Kenya conducted one study on consumer awareness about Fortified Foods using binary logit regression, it has been found that 26% of the subjects were aware of Vitamin A importance, 34% were consuming sugar Fortified with Vitamin A and nearly 55% were aware but not consuming Fortified sugar in Kenya (Pambo et al., 2014b).

A study conducted in Australia on Consumer Awareness, Attitudes and Behaviours to Fortified Foods reported that the participants were skeptical regarding mandatory Fortification of foods due to concern for increased prices of the products because some big companies were Fortifying their brands voluntarily, thus making it more expensive considering it to be healthy. Another concern of the participants was regarding the naturally occurring nutrients that the ones induced through technology. The study reported low awareness of folate amongst the participants, regarding its health benefits and its sources, only women who had experienced pregnancy in the past reported good knowledge of folate. One of the limitations of the referred study is that it has not given definite percentages (Rowland and Dugbaza., 2010).

A study conducted in China assessed Awareness, Attitude toward the Industrial Food Fortification in Mongolia and Harbin district. The survey collected the data from men and women between 2014-2017 aged more than 18 years. Less than half a percentage of people were aware of food Fortification, the survey questioned the participants about its acceptance and recorded that 50% of the participants from Mongolia and 18% of participants from Harbin favored food Fortification on learning the purpose of it (Bromage et al., 2019).

A cross-sectional study was conducted in 13 different countries for assessing Fortification awareness using a structured questionnaire. The survey assessed the information of 1435 respondents. The awareness was limited to 28% of the respondents, the major source of knowledge being the radio for 27% of the respondents. The subjects could mark the correct response for the risk relating to deficiency of micronutrients (76%) The study assessed the association with the occupation of the participants with $P< 0.001$, household size, education level, and age. The study also noted that respondents lying in the above age bracket had better knowledge of nutrients than their younger counterparts. The knowledge regarding different micronutrients was limited in the study (Linda et al., 2020).

A study conducted amongst 150 urban women in Delhi, reported good (48%) awareness of the Fortified Foods logo, where 69.8% agreed to the consumption of Fortified Foods as essential (Premkumar and Garg., 2020). An interventional study conducted by (Sirohi et al., 2015), amongst 400 subjects, recorded awareness of Fortification-- as 12% at the baseline which increased to 72% after the intervention. A study conducted in Kenya on 1435 subjects found that only 28% of the respondents had awareness of Fortified Foods (Linda et al., 2020).

A study conducted in NkowaNkowa Township, Africa, to determine the awareness of women on Fortification reported that 57% of the participants were able to define Food Fortification correctly, and 72% of the participants were aware of the foods that are being Fortified, the staple that is being Fortified in South Africa is maize, which was reported by 70% of the participants. The target group for which Fortification is essentially being done are the children (<6 years of age) who were answered correctly by 72% of the participants (Motadi et al., 2016). The possible reason for better awareness amongst the Africans was the mandatory use of the Fortification logo on bread, flour, and maize, however, in India, the +F logo for identification of Fortified Foods was created in 2016 after the development of the food Fortification resource center (Teaotia and Singhal., 2020).

Fortification in South Africa was started with iodization of salt in 1995 and Fortification of maize and wheat with Vitamin A, thiamine, riboflavin, niacin, folic acid, zinc, B6, and iron in 2003 with the aim to deliver 33% of the RDA per serving to eliminate micronutrient deficiency in the South Africa population (Acham et al., 2012b).

Apart from being cost-effective, food Fortification is the easier and more practical approach well, as it doesn't pressurize people to change their food habits, thus making it a more effective strategy. This strategy can only be successful if consumers will be aware of the importance of including Fortified Foods in their diet and taking the final decision to purchase these products, which can be addressed through advocacy.

The world is becoming digital and due to advancements in technology major source of new information is the internet and mobiles for consumers to keep a track of new information, mobile phones are also being used in Kenya for advertising purposes as people are becoming advanced and it is easy to create awareness using mobile as a medium for advocacy (Pambo et al., 2014a).

A cross-sectional study was conducted in Jaipur in 2012 amongst the 300 rural and urban mothers from the health center. The data used a structured questionnaire for assessing the knowledge of food Fortification. The study revealed a total of 53% of rural mothers and 65% of mothers from the urban area were consuming the targeted Fortified food products, the source of knowledge being the doctors and health care workers for 71% of rural mothers and 65% of urban mothers. Few of the mothers were not consuming Fortified Foods for the reasons it was unavailable (73%) and at higher prices (22%). The researcher linked the low level of awareness with the subject's literacy levels. Low consumption of Fortified Foods was linked to children who were moderately or severely malnourished due to poor dietary practices (Nagaraj et al., 2013).

Studies conducted in India and at the Global level so far have proved Fortification as one of the solutions to improve the Micronutrient level of the person (Khadgawat et al., 2013) (Gera et al., 2012).

A study conducted in Kenya on males/females for consumer awareness of Fortified Foods revealed that the females are less likely to be aware of Fortification due to exclusive control over media and other information by men (Pambo et al., 2014b).

A study conducted in Tanzania on Caretakers of Kinondoni Municipality revealed that only 8% were able to define micronutrient deficiency and more than 50% of the Mother/Child Caretakers were not aware of the health benefits of the micronutrients Thus, the knowledge and awareness regarding food Fortification are very low and there is need to conduct Advocacy (Kasankala et al., 2018).

A study on awareness and consumption of Fortified Foods among female adults (N=100) was conducted in Mumbai. Over 43 subjects were aware of the definition of food Fortification and 52 subjects knew that salt should be compulsorily Fortified with iodine in India. 27% of subjects knew about various vitamins and micronutrients used as Fortificants while 33% of subjects gave mixed responses. Hence, although the consumption was unconsciously more due to the availability of such products in the market (Battalwar and Syed., 2017).

2.2.3.3 Lack of Dietary Diversity as a Factor of Micronutrient Deficiency

Micronutrient deficiency also known as Hidden Hunger, is affecting all people irrespective of age, sex, demography, education, etc. Micronutrient deficiency is one of the reasons for high stunting rates in India, one of the ways to detect deficiency is through the dietary diversity score of an individual, it is important to have variety in the diet to fulfill the needs of each micronutrient.

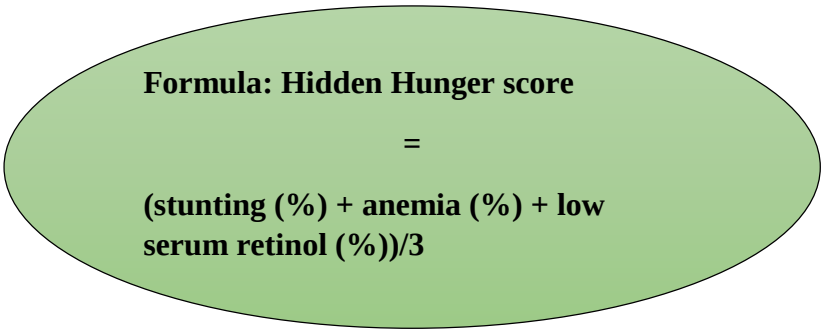


Figure 2.4: Calculation formula for Hidden Hunger

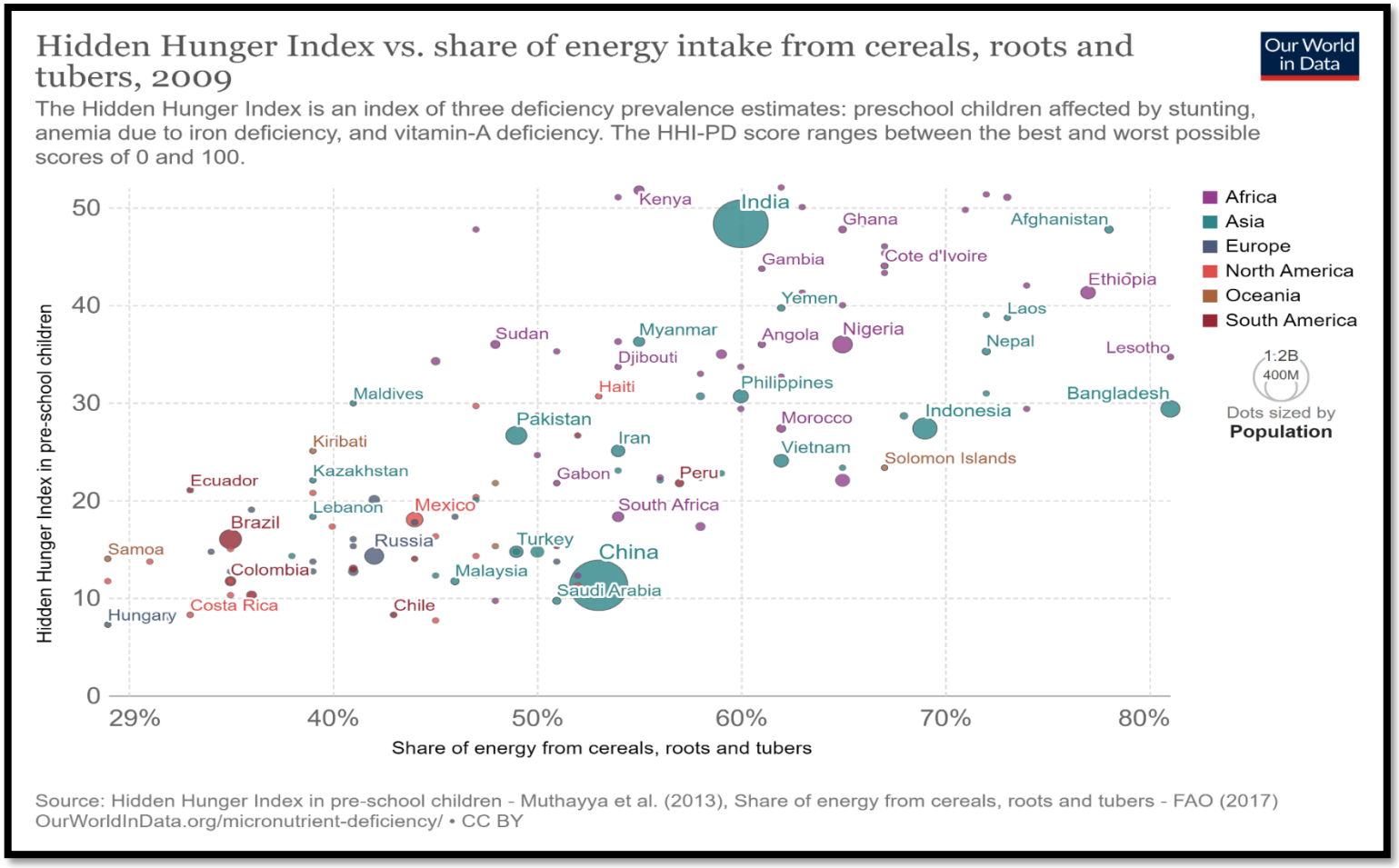
The hidden hunger Index takes into account three major indices- stunting, iron deficiency, and Vitamin A deficiency amongst preschool children.

Figure 2.4 shows that 60% of the Indian population gets their requirements for energy from roots, cereals, and tubers. Twenty countries have reported the highest Hidden Hunger Index scores where India is one of the contributors with an alarming score of 48.3. The report can

be used as an advocacy tool for Fortification to come into play and provide essential micronutrients. The share of micronutrients in the total burden of disease in India is 7% which cannot be ignored any further (Muthayya et al., 2013).

A study was conducted in Pediatric Outpatient Department at Rajeshwari Medical Hospital on children 6month-23 months to assess the minimum dietary diversity using 24-hour dietary recall, according to WHO consumption of four food groups in a daily diet out of seven is considered to be the Minimum Dietary Diversity Score for Children (N et al., 2018).

Children with a lack of Vitamin A deficiency experience serious complications and severe illness. It has been reported that half of the children lose their life within 12 months of losing their sight due to vitamin A deficiency. Nearly 250 million preschool children suffer from Vitamin A deficiency of which the majority (500,000) become blind. Similar findings have been reported for iron deficiency anemia which affects 50,000 women and 18 billion babies lack essential requirement for iodine which hampers their mental growth. Twenty percent of cases of maternal hemorrhage have been associated with iron deficiency and 800,000 people globally die due to zinc deficiency. There are various interventions taken up by the different governments in various countries, however, the one with maximum reach and cost-effectiveness has been Food Fortification. The adoption of Fortified Foods will not alter the food habits of the population while providing them with the essential micronutrients (DSM., 2017)



Source: (DSM., 2017)

Figure 2.5: Hidden Hunger and The Energy Intake from Cereals

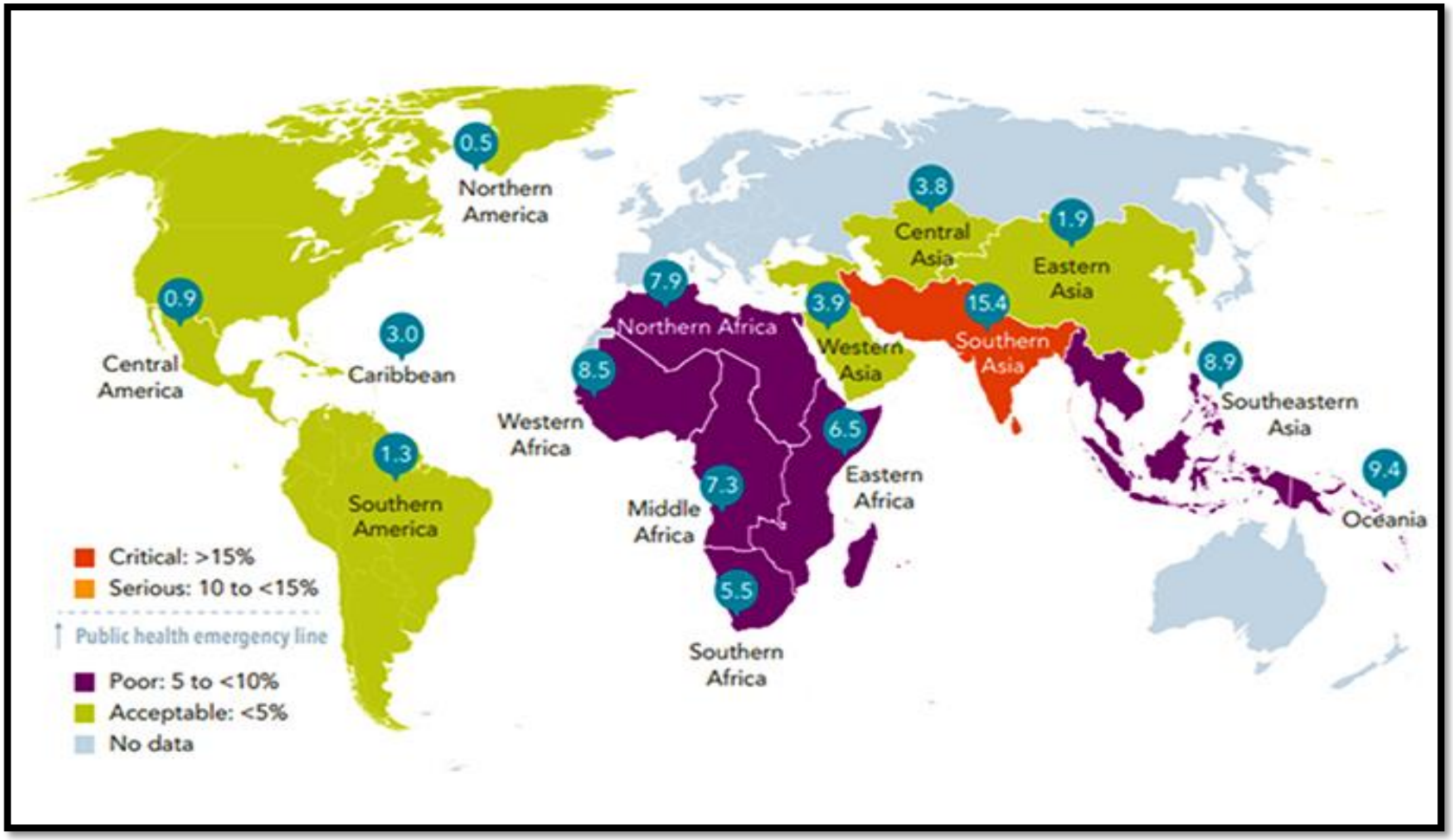
Indonesia has been Fortifying its Oil with Vitamin A, in 24 villages of west Java, since the staple diet focuses more on rice and vegetables where the vitamin A content is limited. The limited variety in the diet of Indonesians and the poverty results in the majority of Vitamin A deficiency. Fortified oil has contributed to the daily intake of Vitamin A by 26-40%, which observed a fall of 18-6% in the total deficiency rates amongst the selected villages. From the abstract in Public Health Nutrition, December 2014 Vitamin A-Fortified cooking oil reduces vitamin A deficiency in infants, young children and women: results from a program evaluation in Indonesia (Sandjaja et al., 2015) (GAIN., 2015)

Globally, junk food consumption has increased especially among children and adolescents. Junk foods are often labeled as foods high in salt, sugar, calories, and fats and they lack important micronutrients like iron, zinc, iodine, and vitamins like Vitamin A, Vitamin D, Vitamin B12, etc. Junk foods provide the feeling of fullness, however regular consumption of such foods deprives people of access to important micronutrients which are important for carrying out major functions in the body, thus leading to obesity and Non Communicable Diseases. According to a study it has been calculated that the lack of fresh fruits and vegetables has led to DALYs i.e. Disability-adjusted life years amongst 16 million of the world's population and 1.7 million people are on the mortality radar. Junk food consumption has been observed amongst both families with good and poor socioeconomic status, thus it cannot be said that price parity is the hindrance behind purchasing the healthy food options or consumption of fruits and vegetables. A cross-sectional study was carried out amongst natives of Kaski district, Nepal. A total of 538 adolescents participated and gave in their inputs in a structured questionnaire. It was observed that approx. 60% of the adolescents were consuming junk foods in the last third days (Month), of which 58% were fond of consuming salty snacks and 57% preferred sweets. Despite adequate knowledge among children about a balanced diet and the harmful effects of junk foods, students were opting for junk foods due to their availability and affordability (Bohara et al., 2021).

The major sources are eaten as a staple in India like cereals, roots, and tuber, which are energy dense and provide and fulfill the calories requirement of the body, however, are deficient in essential micronutrients. To meet the daily requirement of micronutrients, it is essential to have diversity. Due to affected availability and affordability, people from low socioeconomic classes lack the inclusion of other food groups in their daily diet and thus consume energy-dense foods (Neufeld et al., 2017) and (Kweba., 2019). Our world in Data assessed the hidden hunger i.e.

micronutrient deficiency and the common foods consumed worldwide with their share of energy. In India, 60% of the energy is derived from cereals, roots, and tubers, and the prevalence of hidden hunger amongst preschool children accounts for 48% (1.22 billion people). The countries with low Gross Domestic Product per capita have more no. of cases hidden hunger compared their counterparts. India stands amongst the lowest GDP groups with $3,794.76 according to 2011 International standards (Ritchie and Roser., 2017).

Figure 2.5 depicts critical needs for India which has a prevalence rate of more than 15% and needs immediate action to be undertaken, followed by Africa which stands between 5-10%. India accounts for 185 million people lacking the essential micronutrients in their diet. Vitamin D deficiency among children under five is 70% and the prevalence of vitamin A deficiency is 57%.



Source (Bresnyan and Gadha, 2018)

Figure 2.6: Micronutrient Prevalence across the Countries

Policies like MDM, ICDS, and PDS though made an effort to contribute to the diet of the people, by providing minimum calories, however, these policies created a lopsided by focusing more on cereals like wheat flour and rice, which further left the people food insecure. These diets lack the provision of fruits and vegetables, thus catalyst the mono diets and depriving the people to achieve minimum dietary diversity which is having 4 or more 4 food groups in the daily diet (Ruel., 2003). Even according to NFHS 4, only 9.6% were found who are being fed a minimum acceptable diet whereas according to CNNS that figure declined to 6.4% According to the report published by ICMR on 'What India Eats' (Hemalatha et al., 2020) it has been found out that irrespective of regional disparity and socioeconomic classes, cereals are the most commonly consumed food groups. The ICMD and NIN have recommended a daily portion of various food groups which is being called a daily plate, that should consist of 45% of cereals, 17% of pulses and other protein rich foods like eggs and chicken, 12% to oils and fats, and 10% to milk and milk products, 8% for nuts and seeds and rest of the 8% to fruits and vegetables (R. Kaur et al., 2022).

Dietary Diversity amongst any individual is considered as improved health status/outcome. A study was conducted amongst women from 3600 households in 4 districts in India using dietary scores. The study collected the data using 24 dietary recalls for 7 days and considered 37 food items. The WDDs and HDDs recorded that women eat fewer food groups as compared to the household's dietary diversity by 0.1 to 0.5, the major food groups lacking in the women's diet are Vitamin A-rich fruits and vegetables. The results of the study are similar to other studies conducted in Uttar Pradesh, Bihar, and Orissa (2 districts), which were the other sites of the study. Women were consuming less GLV by 9.6%, vitamin A-rich fruit by 22%, Meat fish, and Poultry products by 16.7%and dairy products only 16% of the women were being consumed in the selected households (Gupta et al., 2020).

The report on Global Burden of Disease (IHME., 2017) states that approx. 19.1% of Indian children out of 5351900 infants under the age of 6 months were not exclusively breastfed by their mothers whereas other children were having less consumption of fruits, vegetables, and protein rich foods, thus leading to deficiency of various micronutrients and causing the child's to be stunted or underweight (Bhattacharjee et al., 2021)

A meta-analysis was conducted from 4302 literature of which 270 articles collected the primary data on micronutrient deficiency of various nutrients across India using the Preferred Reporting

Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The estimated figures showed the prevalence of iodine deficiency by 17%, 27% for folic acid, and 54% for an iron deficiency which is a serious cause of concern, 53% for Vitamin B 12, 19% for Vitamin A, and 61% for Vitamin D, further data was segregated based on age group, where iron deficiency was found more common amongst pregnant women by 61%, population with no specific age group had iodine deficiency by 59%. The prevalence of folic acid was 39% in subjects more than 18 years of age, and 41% in subjects less than 18 years of age, thus affecting all the age groups. The study quotes the results of the Vitamin and Mineral Nutrition Information System (VMNIS 2005) which state that anemia affects nearly 1.62 billion people which consists of 24.8% of the total world's population (Venkatesh et al., 2021).

Fortification is not a new concept, it started 100 years ago in different countries Fortifying their staple foods. India started Fortification in 1953 with Vanaspati which was Fortified with Vitamin A and D and salt Fortification in 1962. In Switzerland, the Fortification of Iodized salt started in 1923, the map depicts the year and the staples Fortified in different countries. Denmark started Fortification of Oil and Milk with Vitamin in 1918, Indonesia in 1996, New Zealand in 2007, and Mexico in 2002. Fortification of Sugar and Wheat Flour with Vitamin A started in the USA, the UK in 1923, Malaysia in 1985, Thailand in 1993, Mexico in 2002, chile in 1997 with other countries like central America, Phillippines, Costa Rice, Puerto Rico, Trinidad, and Tobago. The timeline further highlights the history of Fortification in different countries (Gulati., 2018a). (Figure: 2.6)

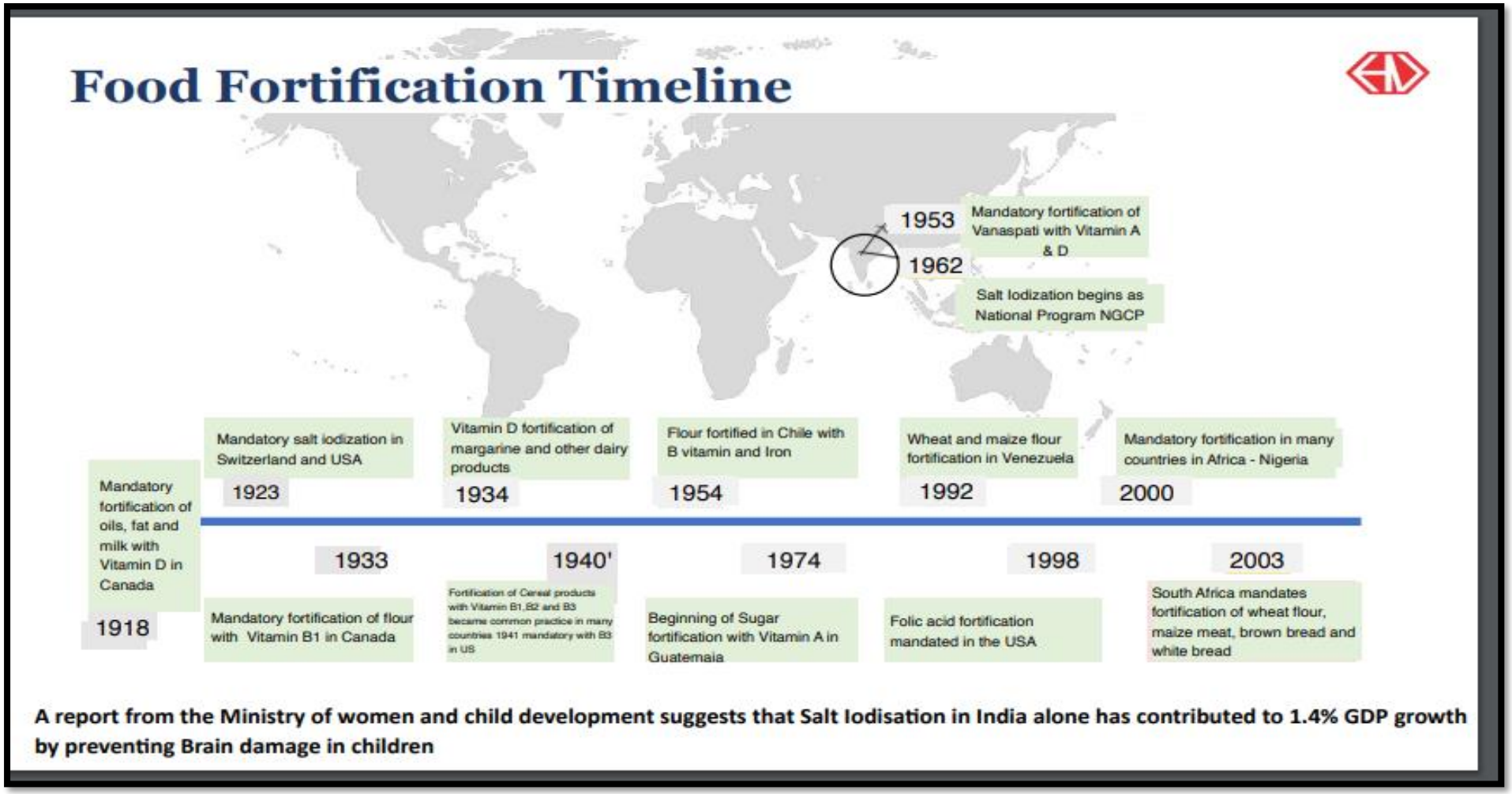


Figure 2.7: History of Food Fortification Worldwide (Mandke., n.d.)

2.3 Fortified Staples in India

2.3.1 Milk Fortification

Food Fortification is the enrichment of foods with certain nutrients that otherwise are missing in the food. One of the regulations on food Fortification states that the 'Levels of Food Fortification have been adjusted to provide 30-50% of RDA' thus a product needs to provide 30-50% of RDA to be able to use the +F logo (MoHFW and FSSAI., 2018)

Food Fortification is not a new concept in India. It started way back in 1962 by Fortifying salt with iodine, Fortification of milk with Vitamin A andD in 1980, and Fortification of Vanaspati with vitamin A in 1953 (Gulati., 2018b). Currently, there are many programs and schemes which are focusing on specific micronutrient deficiencies like National Nutrition Mission, ICDS, MDM, PDS, Eat Right Moment, Anemia Mukt Bharat, etc., especially for the LIG families but few programs have been initiated on Food Fortification for the general population as a whole.

According to National Nutrition Monitoring Bureau 2012, 62% of the population in India has low levels of blood serum for Vitamin A whereas about 50-90% of the population is deficient in Vitamin D, thus giving way to the health consequences amongst the people (NIN., 2012).

Milk in India is being Fortified with Vitamin A and D as milk is considered one of the staple diet which is consumed by every socioeconomic group, it is important to Fortify milk as vitamins in milk gets depleted upon heating, these vitamins are present in the top fat layer on the milk, formed after giving a boil to the milk, thus Fortifying milk helps in retaining these vitamins back to milk which is water soluble form of Vitamin A and D, so that even after removing or discarding the fat layer from the boiled milk, these vitamins will be present, thus being beneficial for the consumers.

All kinds of milk are being Fortified, toned, double toned, full cream, or no fat milk so that low-income population groups, who buy no fat milk to save their money and also cater to the needs of the population who prefer no fat milk can also be benefited.

NDDB Foundation for Nutrition (NFN) has started the program 'Gift Milk' as a part of their CSR activity where 200ml of Fortified flavored milk is being distributed to children studying

in government schools aged 5 -15 years. NFN has so far distributed 44000 units of milk to children which covers 94 schools in 7 different states (as of March 2019). In efforts to measure the impact, a study was being conducted by the Rajendra Institute of Medical Sciences (RIMS) located in Jharkhand, Ranchi. The study reported improved cognition amongst 24% of children, improved serum vermin B12 levels, a decrease in anemic children, and better IQ (16%) than their counterparts (control group). Apart from this, the program has also increased the attendance of the children by 10% (NDDB., 2019).

Milk is being Fortified at 25-30% of the recommended dietary allowance, which is much below the toxic levels, the values are set by FSSAI 2018 regulations keeping in mind, the upper tolerable limits, hence, making Fortification a safe strategy to combat malnutrition amongst the general population. Milk undergoes some micronutrient loss of 10-15% on boiling as per FSSAI (FSSAI., 2018c).

There are various Diary Cooperatives and private dairies that have joined hands to Fortify tones of milk for the need of the community. The cost of Fortifying milk has been kept low so that it doesn't pressurize the dairies and can easily cater to the needs, the cost is 2 paise per liter of milk which is cost-effective and sustainable (FFRC., 2020).

Fourteen countries have mandatory milk Fortification legislation; however, it was initially started way back in 1935 in a few of the countries. According to scientific evidence (FSSAI., n.d.-b), eleven countries are Fortifying milk with Vitamin A and D, similarly to India's legislation, whereas Costa Rica is Fortifying with Iron, folic acid, Vitamin A, and Vitamin D, and China and Canada are adding Calcium additionally to milk. According to the study conducted by (Sazawal et al., 2007) on milk Fortification in the urban north India amongst the children aged 1-3 years, who were fed Fortified milk (N-316) and others who were in the control group (N=317), Fortified milk has been beneficial in reducing the prevalence rate of diarrhea by 18%, pneumonia by 26%, and high fever by 7% and severe illness by 15% percent, since Vitamin A and Vitamin D have a well-known advantage of boosting the immunity against infections. The study delivered 21 sachets of Fortified milk 32 g serving which needs to be fed to children thrice a day. Fortified milk consumption for one year has been providing additional zinc (7.8mg), Iron (9.6mg), selenium (4.2 µg) Copper (0.27 mg), Vitamin A (156 µg), Vitamin C (40.2mg), and Vitamin E (7.5mg), every day. Additionally, these sachets also had extra Vitamin C for better absorption of iron, and copper. Though milk naturally has some vitamin

A and D in it, however during boiling the removal of cream and fat leads to the loss of these vitamins, since they are fat soluble nutrients.

Table 2.1 Indian Dairies practicing Fortification of Milk

Dairy Cooperative	Private Dairies
1. Chhattisgarh State Co -Operative Marketing Federation Ltd. Devbhog 2. Delhi Milk Scheme (DMS) DMS 3. Haryana Dairy Development Cooperative Federation Ltd. Vita 4. Jharkhand State Cooperative Milk Producers Federation Ltd. Medha 5. Maahi Milk Producer Company Ltd. Maahi 6. Madhya Pradesh State Cooperative Dairy Federation Ltd. Sanchi 7. Mother Dairy Fruit and Vegetable Pvt. Ltd. Mother Dairy 8. Odisha State Cooperative Milk Producers' Federation Ltd. OMFED 9. Punjab State Cooperative Milk Producers Federation Ltd. Verka 10. Rajasthan Cooperative Dairy Federation Ltd. Saras 11. West Assam Milk Producers' Cooperative Union Ltd. Purabi 12. Uttarakhand State Dairy Coop. Federation Ltd. 13. Bihar State Milk Co-operative Federation Ltd. Sudha 14. Pradeshik Cooperative Dairy Federation Ltd. Parag 15. Karnataka Milk Federation 16. Nalgonda Milk Union 17. Maharashtra Rajaya Sahakari Dugdh Mahasangh Maryadit Mahanand Dairy 18. Krishna Milk Union	1. Britannia Industries Ltd. 2. Cream line Dairy Products Ltd. 3. Dairy power Ltd. 4. Goma Foods Pvt. Ltd. 5. Heritage Foods Ltd. 6. Kwality Ltd. 7. Milky Moo PAN 8. Nestle India Pvt. Ltd. 9. Uttar Pradesh Pradeshik Cooperative Dairy Federation Ltd. 10. Sunfresh Agro Industries Pvt. Ltd. 11. Prabhat Dairy Uttar 12. VRS Foods Pvt. Ltd.

Source: (Food Safety And Standards Authority Of India, 2018)

Despite the benefits of Fortified milk, there has been some difference of opinions among the various scientist, academicians, etc. regarding the cost of Food Fortification. FSSAI has calculated the cost of milk to be 2 paise per liter of milk and other staples, making Fortification a cost-effective one. These minimal costs invested for the health of the country's people will reduce the cost of health care, and also the burden on the economic status of the country. The Copenhagen census has reported, that one rupee spent on the Fortification procedure will provide 9 times benefit to the country and its economy which further will promote the overall growth and development of the country (FSSAI, n.d.-a) and (Copenhagen Consensus., 2008).

Table 2.2: Cost of Fortification in an Open market

	Wheat Flour	**Rice**	**Milk**	**Edible oil**	**DFS Salt**
Cost of Fortification per kg (in Rs)	0.08-0.10	0.80	0.015	0.08-0.10	2-3
Cost of Fortification, Processing, Packaging per kg (in Rs)	2.5	1.7	0.015	0.08	00

Source: For salt (MOHFW., 2017)

Source: (Gulati., 2018b)

Although it's a fact that Fortified milk is beneficial and one glass (320ml) is providing 34%, Vitamin A and 47% of Vitamin D, few the companies are not ready to Fortify their brands, to fill in the gap, National Dairy Development Board (NDDB) has partnered with South Asian Food and Nutrition Security Initiative (SAFANSI), the World Bank and The Indian Nutrition Initiative, Tata trust for joining hands and helping in scaling up the food Fortification. The partnership of NNMB with various other organizations has led the 10 milk federations, and dairy producers to start the trail of Fortified milk for their respective brands, which is indeed a great step toward fighting the micronutrient deficiency (Bresnyan., 2018).

2.3.2 Rice Fortification

Rice is another suitable vehicle for Fortification since its being widely consumed by people in different countries, other than wheat flour. The countries with the majority of rice eaters can address the micronutrient deficiency by Fortifying rice with Iron, Vitamin B12.

Most of the rice is being produced by Indonesia, Bangladesh, and India. It becomes important to Fortify rice, as nutrients are lost during the harvest, milling, and polishing process. Rice is a staple of 65% of the Indian population, thus Fortifying it will help in bridging the nutrient gaps (Department of Food and Public Distribution., 2020).

An efficacy study conducted by TATA TRUST from 2018 to 2020 in Maharashtra district, Gadchiroli, saw improved status in the prevalence of anemia by providing Fortified rice through the PDS system for one year. The study observed a reduction in anemia cases by 21.4% amongst women, adolescent girls, and children (FFRC and FSSAI., 2020).

Another study conducted for six months amongst the 250 school children (5-8 years of age) in Punjab examined a significant improvement in the status of Hemoglobin and serum ferritin amongst the children who were being fed Fortified rice through the school meal program. The study blended the Fortified rice with other rice in a ratio of 1:100 which didn't change the taste of the rice and was thus acceptable to the children (Hussain et al., 2014).

There are multiple scientific publications from different countries which states that rice Fortification improves the health status of the people by improving the HB, Vitamin A, Zinc, Folic acid, and Vitamin B12 status. There is minimal loss of micronutrients during the process of cooking rice through boiling or pressure cooking. A study conducted on the retention of nutrients in cooking rice in 5 different ways i.e. absorption method with or without soaking, washing before cooking, cooking in water, and frying rice before cooking, records the retention of micronutrients (Iron, Zinc excess, Vitamin B12, and folic acid) between 75% and 100% with an exception for Vitamin A which doesn't retain during cooking in excess water whereas having 80% of retention when cooked using the soaking technique (Wieringa et al., 2014).

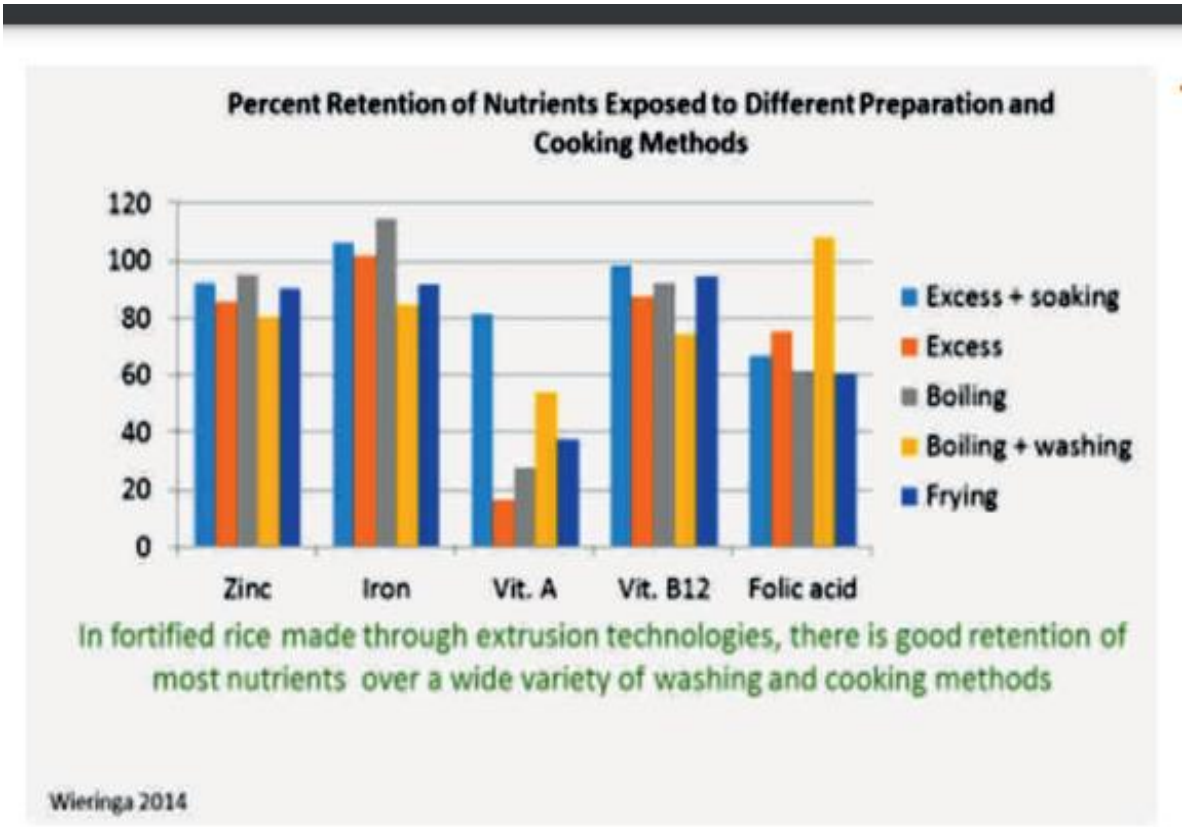


Fig 2.8 Retention of Nutrients after cooking

PATH has been working in different countries on Rice Fortification. In Burundi, PATH, World Vision, and UN World Food Programme (WFP) are conducting research on efficacy trials in the local community for testing the operational feasibility amongst the school children. Similar studies are being undertaken in Cambodia, India, Myanmar, Vietnam, Nigeria, and Brazil (Aung., 2017) (PATH., 2019).

In India, 2700 rice mills have been installed for Fortification where India's blending capacity is 13.67 lakh tones across 14 states. The Central Government has passed a notice for supplying Fortified rice in Government schools to children through Mid-Day Meals and ICDS which will further scale up to PDS. Andhra Pradesh, Gujarat, Maharashtra, Tamil Nadu, and Chhattisgarh have started the Pilot of distributing Fortified rice out of the 15 states identified by the government (Patro., 2022).

2.3.3 Wheat Flour Fortification

The staple diet of most Indians re Cereals and Millets. Thus Rice and Wheat flour serve as the best vehicle or Fortification. Wheat is grown in India on a large scale and is a part of the

staple diet in India. According to NNMB survey conducted in 2012, Indians consume approx. 375g of cereals in a day. Wheat kernels lose various essential micronutrients during milling and processing such as Iron. Folic acid and Vitamin B12 are stored back with the Fortification process. The average per capita consumption of wheat flour is from 150-to 300 grams. (NIN., 2012)

Gujarat has implemented delivering of Fortified wheat flour in its Social Safety Net Programs (SSNP), namely, ICDS, MDM, and PDS. A study was conducted by (Fiedler et al., 2012), to assess its coverage and the impact on the health of its beneficiaries. The study used the data from National Sample Survey to identify households with deficiency of micronutrients and their daily intake amongst the beneficiaries. The post Fortification levels showed improvement in the intake of nutrients. Vitamin A intake was enhanced by 34% amongst the beneficiaries of MDM and ICDS whereas, amongst the PDS users, intake of iron was enhanced by 94%. Enough studies have indicated the benefits of Fortifying wheat flour on the improvement of birth defects and intake of essential micronutrients (Barkley et al., 2015) (Akhtar et al., 2011). Studies have also claimed a reduction in birth defect cases from regular consumption of wheat flour for a year by 31 to 78%.

2.3.4 Oil Fortification

Oil Fortification has a history in India since 1950 when vegetable oil used to get Fortified along with salt iodization, however, due to a lack of the global evidence it was discontinued and gained momentum again in 2016 with developed standards for Fortification of various staples. The most common oils consumed in India are rapeseed oil, soy oil, cotton seed, and groundnut oil which have a penetration rate of 99% of households.

Oils are being Fortified with Vitamin A and D which are both fat soluble vitamins and can retain even after reaching the frying stage (Bhatnagar and Kanoria., 2020) (FFRC., n.d.).

The total oil consumption has been reported as 24 million metric tons (MMT) in India, which makes oil a suitable vehicle since its being consumed by everyone, at all times as a part of the staple diet. The NSSO report, 2014 has reported the consumption of oil by 20-30 grams/per person/per day (NSSO., 2014).

FFRC has conducted training with key stakeholders for oil Fortification for the implementation of the strategy which has bought together a few brands namely Mother Dairy

Fruits and Vegetables Pvt Ltd, Cargill India, Adani Wilmar Limited, and others who have started the process with new FSSAI standards. At present, there is 43% of Fortified oil available in the Indian market which is reaching 325 million consumers. GAIN on the other hand has joined hands with FSSAI and is conducting various meetings for the implementation of the Fortification strategy in different states, Rajasthan, Madhya Pradesh, Haryana, Punjab, Andhra Pradesh, Maharashtra, and Telangana are a few of the states which have been selected for the promotion, since they are amongst the top oil producing states (Tata Trusts., n.d.) (FFRC., 2016).

There is enough evidence available for Oil Fortification. In 1917 Denmark started the oil Fortification of Vitamin A which lead to a reduction in Xeropthalmia cases in the hospital by 90%. Another study observed a decline in the prevalence rate of serum retinol levels. After consumption of Fortified margarine for at least six months, the serum retinol fell from 25% to 10% (Aykroyd and Jolliffe., 1949).

There is minimal loss of Vitamin A, D, and E in cooking, however through repeated frying loss of micronutrients occurs by 20- 25%. It is recommended not to fry in the same oil which has been used once for frying. As it leads to loss of micronutrients (FFRC., 2016).

2.3.5 Salt Fortification

Salt Iodization was launched in 1962 in India under the National Goiter Control Program, and in 1992 it was renamed as National Iodine Deficiency Disorder Control Programme (IDD and Nutrition cell. Ministry of Health and Family Welfare, 2006). Iodine Deficiency is affecting the world despite its wide consumption on daily basis. Worldwide it is affecting 200 million people and leading to 71 million goiter cases and other disorders. For children aged 6 – 12 years and the first 1000 days are the most crucial time since iodine deficiency leads to psychomotor impairment and affects the growth of the child. Researchers have estimated that 1.88 billion people are at risk of which 241 million are children who are consuming an adequate amount of iodine (G. Kaur et al., 2017). Despite universal salt iodization since 2005, only 71% of households were consuming iodized salt because of non-availability in the rural areas and lack of knowledge amongst the community members. NFHS 5 has reported Daman and Diu, Dadra and Nagar Haveli, and Andhra Pradesh (83%) have minimal consumption of Iodized Salt.

In Switzerland, salt Iodization started in 1920 which has led to mandatory Fortification of

salt in 137 countries in 2019, whereas 68 countries have mandated Fortification for two of the staples to combat the micronutrient deficiency (Gunnal et al., 2021).

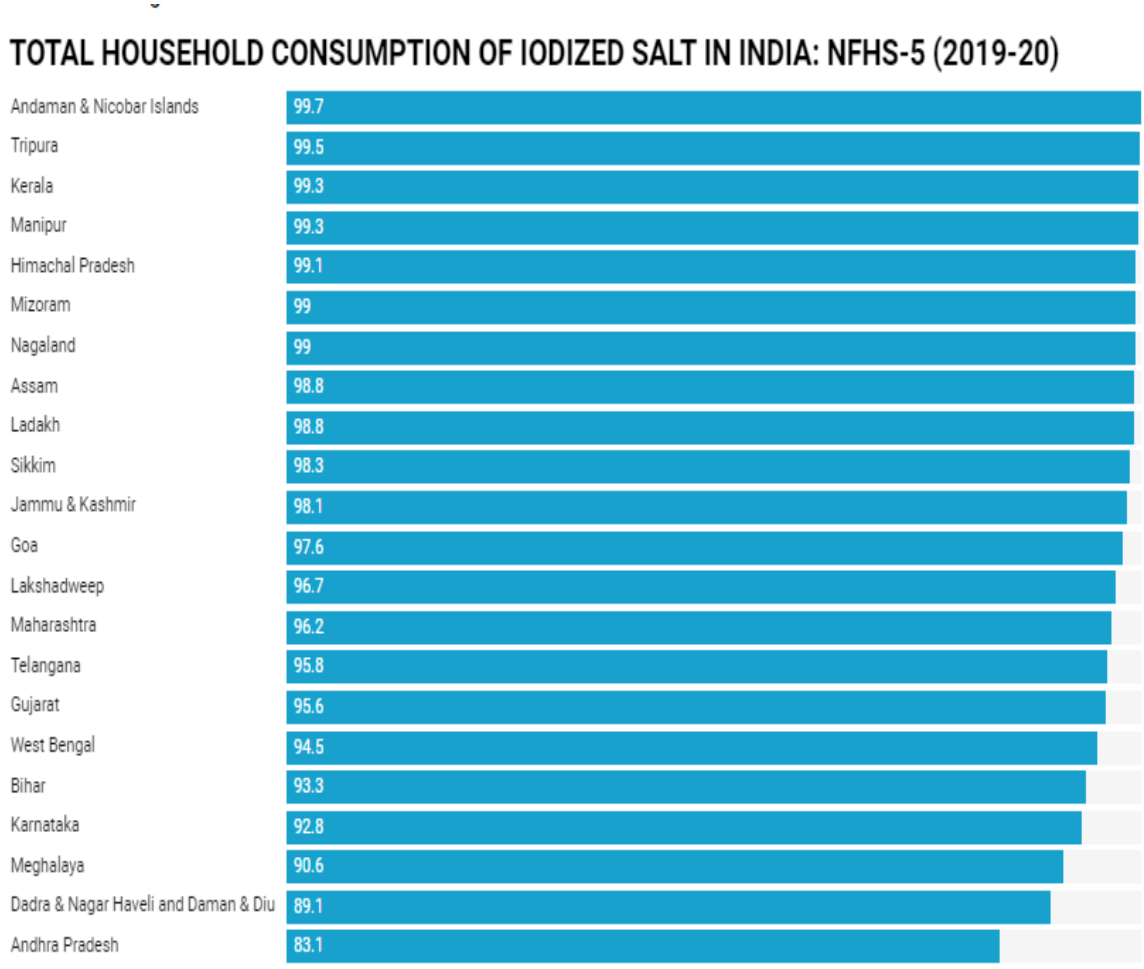


Fig 2.9: Consumption of Salt by Households in India (NFHS 5)

Source: (NFHS 5, 2022) (Gunnal et al., 2021)

A study was conducted to assess the efficacy of Double Fortified Salt (DFS) with iron and iodine amongst 212 women of West Bengal aged between 18 – 55 years. The study was double-blind wherein DFS or a control iodized salt was distributed for 9 months. DFS showed improvement as compared to the control group in hemoglobin, ferritin (34%) and soluble transferrin receptor, and body iron. The study also reported decreased prevalence of iron deficiency after 9 months of consuming Fortified salt (Haas et al., 2014) (Andersson et al., 2008).

It is essential to consume iodine on daily basis and get the recommended dietary allowance, which varies for every age group. Iodine doesn't have any storage organ in the body. Meat,

fish, milk, etc. are a few of the sources of iodine that should be eaten on daily basis, however, to reach the minimum allowance, it is difficult to fulfill the requirements through dietary sources, making Fortification the need of an hour.

Iodine levels have been safely standardized for the Fortification process in the table salt. While cooking, iodine loss ranges from 20- 40% due to the heating process, to compensate for this loss, iodine levels have been standardized by FSSAI considering the safe limit of iodine consumption.

Over 3 billion people are consuming iodized salt as of 2018 according *to* (Mkambula et al., 2018) *in an article published on devex.com. So far, 20 countries have been classified under the red category for utilizing iodized salt below the acceptable limits as per WHO 2017.*

2.4 Fortification and Its Safety

According to the recent studies conducted in Ethiopia and the United States, Fortification for a long time can be toxic, especially when it's consumed along with the supplements or when it is provided to a population with mild deficiencies, (Dwyer et al., 2015) (Dasa., 2019). Hence it has been stated that for Fortification to be implemented there should be enough dietary gaps in the diet of the targeted population, levels set for Fortification should be low, (Table 2) and changes in dietary habits of people should be kept in mind (Neufeld et al., 2019). Currently, a Fortificant range has been developed by FAO/WHO as per the standards which are well below the upper tolerable limit, premix added to foods as Fortificant is less than 0.02%, and thus it is safe to consume Fortified food. (MoHFW and FSSAI., 2018) Also, as per the 68th round of Nutritional Intake in India report, conducted by NSSO, GOI (2011-2012), people in India have a very low intake of fruits (30g/day) and vegetables (<50g/day) which are far less than the recommended intakes (NSSO., 2014). This means Indians are lacking certain micronutrients in their diet and so Fortification can currently be used as a vehicle to improve their micronutrient status.

2.5 Fortification Logo and Claims

On 11th August 2017, FSSAI launched the Fortification logo ' +F' which will enable the consumers in identifying the products with added micronutrients in them. FSSAI has issued clear guidelines on the size, color, and display of the +F logo on the front label of the product.

+F logo has to be displayed on the packet, clearly mentioning the nutrients the product is getting Fortified with.

Fortified products like milk, Double Fortified Salt, Rice, Oil, and wheat flour will have a +F logo which will be a mandate, additionally, producers and manufacturers are allowed to have the nutritional claims for the Fortificants the product carries to advocate the benefits of the product (MoHFW and FSSAI., 2018).

S. No	Nutrients	Claims
1	Vitamin A	Helps against Night blindness;
2	Vitamin D	Supports strong bones;
3	Vitamin B12	Important for maintaining normal functioning of Nervous system and blood formation;
4	Folate & Folic acid	Important for foetal development and blood formation;
5	Iron	Fights Anemia;
6	Iodine	Required for normal growth, thyroid and brain func-tion;
7	Zinc	Supports a healthy immune system;
8	Thiamine	Required for normal nerve and heart function;
9	Riboflavin	Necessary to release the energy from food;
10	Niacin	Necessary to release the energy from food;
11	Pyridoxine	Necessary to release the energy from food.

Fig 2.10: Claims on Fortified Products by FSSAI (FSSAI, 2018b)

Fortificants have been curated safely by FSSAI considering the safety and toxicity levels of each nutrient being used as Fortificant.

Table 2.3. Fortificants and their levels in staple foods (MoHFW and FSSAI, 2018)

S.no	Component	Level of Nutrients
1	**Salt when Fortified with Iron and Iodine**	
	Iodine	20-30 ppm (Manufacture level
	Iron	850-1100 ppm
2	**Fortified oil**	
	Vitamin A	6 ug RE-9.9 ug RE per gm of oil
	Vitamin D	0.11 ug-0.16 ug per gm of oil

3	**Fortified Milk**	
	Vitamin A	270 ug RE-450 Ug RE (per liter)
	Vitamin D	5 ug-7.5 ug
4	**Fortified Wheat Flour (Atta)**	
	Iron	28 mg-42.5mg
	Folic Acid	75 ug-125 ug
	Vitamin B12	0.75 ug-1.25ug
	(other Micronutrients include- zinc, Thiamine, Niacin, etc)	
5	**Fortified Raw Rice**	
	Iron	28 mg-42.5mg
	Folic Acid	75 ug-125ug
	Vitamin B 12	0.75 ug-1.25 ug
	(other Micronutrients include- zinc, Thiamine, Niacin, etc)	

Thus for promoting Fortified Foods at the Community level, It is important to have the availability of sufficient brands Fortifying their products, along with the +F logo which will help in the identification of the Fortified products. Table 3 enlists all the 5 staples and the available brands in an Open Market (FFRC., 2018).

Table 2.4: List of Fortified Foods available in an Open Market in Gujarat or PAN India

Mode of Fortificant	**Company Name**	**Brands**	**Gujarat/ PAN India**
Fortified Wheat Flour			
1.	Future Group	Golden Harvest	PAN India
2.	Mishkat Agro Industries	Energetic	Gujarat
3.	General Mills Pvt Ltd.	Pillsbury	Gujarat
4.	Patanjali Ayurved Ltd.	Patanjali Aata	PAN India
Fortified Rice			
1.	DCP India Pvt Ltd.	Asbah	PAN India
2	LT Foods	Daawat (Rozana)	PAN India

Fortified Oil			
1.	Adani Wilmar Pvt Ltd.	Fortune, Fortune plus, etc	PAN India
2.	AAK Kamani Pvt Ltd.	Komal, Jawan, Classic	PAN India
3.	Cargill India Pvt Ltd.	Gemini	PAN India
4.	Kriti Nutrients Lmt	Kriti	PAN India
5.	Marico Ltd.	Safola Active etc	PAN India
6.	New Bharat Oil Mill	Parmatma Mustard Oil	PAN India
7.	Mother Dairy, Fruit and Vegetable Pvt Ltd.	Dhara	PAN India
8.	AP Organics Ltd.	Hudson Canola oil etc	Gujarat
9	Frigarifico aalana pvt ltd.	Sunny priya radhuni etc	Gujarat
10	Patanjali Ayurved Ltd.	Patanjali Mustard oil and ranges	PAN India
Fortified Milk			
1.	Maahi Milk Producer Company Ltd.	Maahi	Gujarat
2.	Mother Dairy, Fruit and Vegetable Pvt Ltd.	Mother Dairy	PAN India
3.	Britannia Industries ltd.	Britannia	PAN India
4.	Kwality Ltd.	Kwality	PAN India
5.	Nestle India Pvt Ltd.	Nestle a+ Nourish	PAN India
Double Fortified Salt			
	AnkurChem Food Ltd.	Ankur Salt Plus	PAN India
	Indo Brine Industries Ltd.	Dandi, INDO, Kohinoor	PAN India
	Super salts Pvt ltd.	Top Line	Gujarat
	Tata Chemicals pvt ltd.	Tata Salt Plus	PAN India
	Chirani Salt India Pvt Ltd	Sun Gold Plus	Gujarat
	Western India sea Brine Pvt Ltd.	I-Power SNP	Gujarat

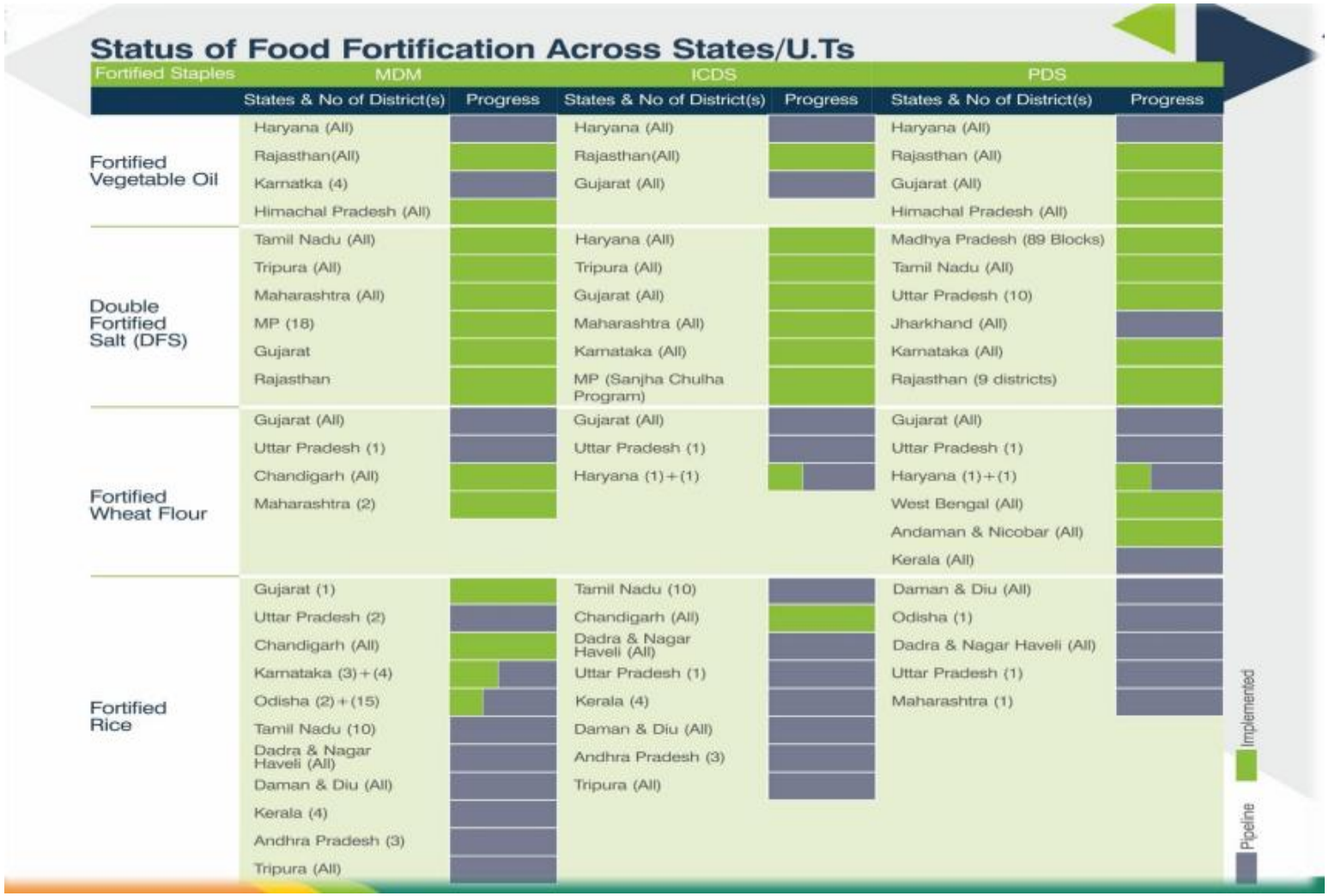


Figure 2.11 Current Progress of States/ UTs with respect to Fortification *(FFRC., 2018)*

The government of India has taken a step forward in Fortifying the staples that are provided under Targeted Public Distribution Scheme under a pilot project in 15 states, one district each. World Food Programme has joined hands with India's Ministry of consumer affairs, Food and Public Distribution, and is providing technical assistance for Fortification in India. WFP has conducted its first Training on Food Fortification of rice in Lucknow and is joining hands with private agencies to Fortify rice and wheat, following the gazette standards issued by FSSAI.

WFP will assist in providing training, procurement of machinery, premixes for the Fortification process, setting up the kitchens and cascade training of the premix suppliers, and constant monitoring and evaluation of the process.

Initiatives have been undertaken by WFP in collaboration with the Department of Basic Education of Uttar Pradesh wherein the distribution of Fortified rice and wheat flour has started in schools of Varanasi in December 2018, so far, approximately 367 tons of Fortified rice and 16.7 tons of wheat flour has been distributed through mid-day meal channels, however, some challenges that the organization has faced were regarding the stability issues in government postings which are subject to frequent transfers (WFP., 2020).

A study conducted in Vietnam has recorded that there was reluctance amongst the people regarding the acceptance of Fortified food since staples have been chosen as a vehicle of Fortification which is consumed in great quantities, a however small variation in the prices is a cause of concern for the consumers who are price sensitive and run their house on a monthly budget basis, which could defer the intentions towards other alternative offering cheap prices than their counterparts. To overcome the concern, it is important to have the support of the Governments and Fortify the products at a larger scale by tying up with the private agencies which could help in adopting and technical assistance. Mandatory regulations by the government would help in addressing malnutrition, making Fortified Foods the 'best buys' option for the community. Another important observation marked in the study was the use of social marketing for the identification of the logo, which could be simple, colorful, and visible on the front packaging, however, the challenge was to make the community familiar with the logo and its importance. The 4 P's approach which is Price, Product, Place, and Promotion was adopted as the strategy for influencing the behaviors of the community (Turk et al., 2016).

2.6 Food Fortification Awareness

On August 29th, 2018, FSSAI addressed the widespread micronutrient deficiency in Chandigarh by promoting Fortified Foods and launching 'EAT RIGHT MOVEMENT' which also addresses the capacity building for Fortified Foods. Other states which have taken the lead are Punjab and Haryana. FSSAI conducted a workshop in Chandigarh to engage and sensitize the local media and stakeholders on food Fortification since the majority of the people are unaware of its benefits and are skeptical considering the costs and myths around Fortification. Mass awareness sessions and programs need to be undertaken by researchers, media, and manufacturers for clearing out the doubts of the community people and promote the uptake of Fortified Foods. The standards for Fortification have been carefully decided by the scientific panel of FSSAI and the limits have been set taking into account the toxicity of micronutrients. The standards provide micronutrients for about 30-50% of the daily RDA of nutrients. Chandigarh has taken a step forward by being the first city for adopting Fortified Foods under ICDS and MDM programs which would address approx. one lakh beneficiaries, followed by Punjab and Haryana (FSSAI., 2018b). Currently, 15 states and 3 UTs have adopted Fortification under the safety net programs.

Fortification Assessment Coverage Toolkit (FACT) is a survey developed by GAIN for assessing the coverage of Fortified Foods for the population who is consuming Fortified Foods. The survey was conducted to assess the barriers and determine the coverage of Fortified Foods and their contribution to total RDA. The FACT survey was conducted in cities of Pakistan where mandatory Fortification for oil and ghee started way back in the 1960s, and salt iodization voluntarily since the 1980s. Nearly 704 households were surveyed in Balochistan, 690 from Punjab, and around 710 in Sindh. The market survey observed that there were 30 brands which were available in the local markets for Fortified salt, 149 brands for Fortified oil/Ghee, and 67 brands of wheat flour. The results revealed that oil and ghee were being consumed by 100% of the households, making it universal amongst the study population and 84% were consuming Fortified salt. The consumption of Fortified wheat flour was lower in the households with 52% in Baluchistan, 31% in Punjab, and 63% consumed in the Sindh region. Further calculations revealed that Fortified salt was contributing 31% of EAR on an average for iodine, especially amongst the children between the age of 12-23 months, 39% of children in 24-59 months, and 40% among women of reproductive age (WRA) in Baluchistan, whereas in Punjab it was 45% for children (12-23months), 54% in children (24-59m) and 51% WRA.

For Vitamin A Fortified oil contributed nearly between 35- 45% of the EAR, and approx. 5-12% for Iron in the selected age groups. (*FACT.*, 2018)

2.7 Social Marketing

Social marketing as defined by (Kotler and Lee., 2011) is the; Process that applies marketing principles and techniques to create, communicate, and deliver value to influence target audience behaviors that benefit society as well as the target audiences'. According to Kotler social marketing is applied to improving public health, preventing injuries, protecting the environment, contributing factors, and for enhancement of the wellbeing of the community.

Food security and Nutrition Public Awareness report on advocacy framework launched in Afghanistan in 2018- 2023 provide the lessons on advocacy and SBCC model which is the Social and Behaviour Change Communication strategy. SBCC is a planned process that follows a systematic approach and identifies the barriers and motivators which could help in changing the perception of the people living in the community. The key components of SBCC are Advocacy, social mobilization, and Behaviour Change Communication. Afghanistan had a disrupted nutrition status which could only be changed by involving stakeholders at different levels by the SBCC framework (USAID., 2018).

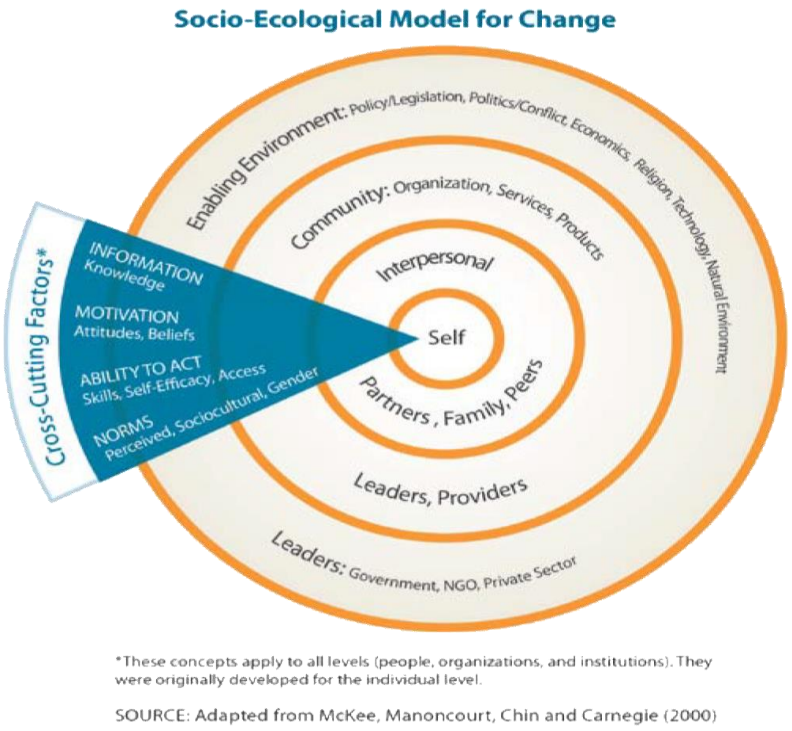


Fig 2.12: Socio-Ecological Model of Change

Dalberg has estimated less than 20% of the production of Fortified products which can be one of the reasons for hampering the uptake of Fortified Foods by the people. For adoption, it is necessary to make the products available in the product. The report has also raised concern regarding the adoption of Fortified products by the vulnerable population. Nearly 40- 60% of products are not reaching due to the unavailability of the Fortified products in the market, thus it becomes important to have strong communication channels to transfer the message regarding the benefits, identification and promote manufacturers to Fortify their products and make them readily available in the Indian market.

Different communication tools, strategies, and models can be used for promotion using behavior change communication through various means for the masses which will help in the uptake of +F products by the consumers and also conducting training sessions with the manufacturers and producers for addressing demand and supply effectively (Bhatnagar and Kanoria., 2020).

It is important to provide manufacturers and producers with support equipment and Fortifying according to the standards issued by FSSAI, regular monitoring, and evaluation of the plant set for the Fortification process, and training of the staff and the employers for the procedure of Fortifying different staples (Mkambula et al., 2020).

Every effort taken for Fortification and to fight micronutrient deficiency will lead to higher benefits for the health of the individual as well as for the economy.

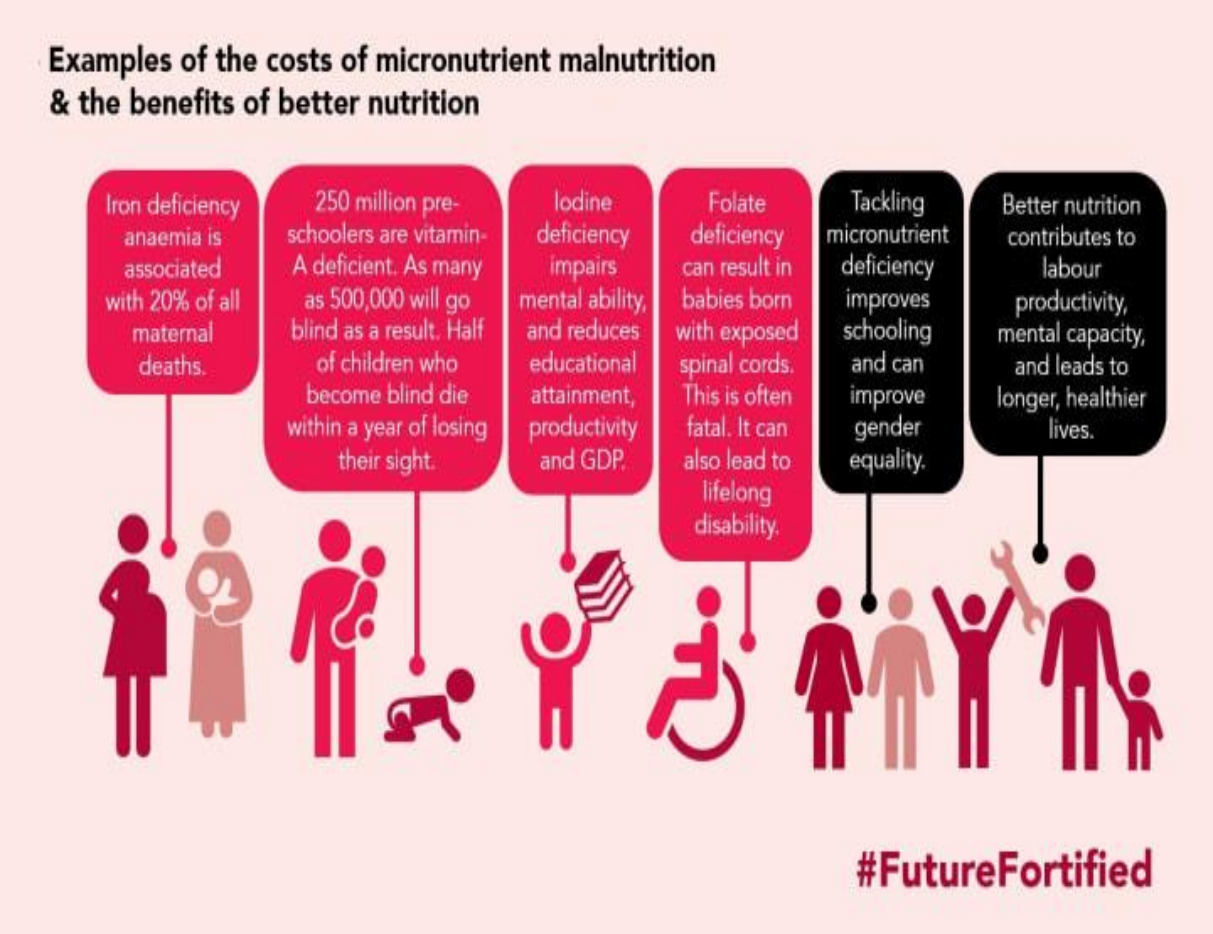


Fig 2.13: Investments in Malnutrition and its Return (Pic Reference: GAIN: Food Fortification for a smarter, healthier, Moe Productive World)

2.8 Food Fortification around the World

Food Fortification imitative provides technical support and assistance to government, Private partners, producers, manufacturers, and agencies for the implementation of food Fortification. The 2021 report of (FFI., 2021a) states that the efforts taken by the agency have helped the countries to reduce micronutrient deficiency for nearly 1.3 billion people.

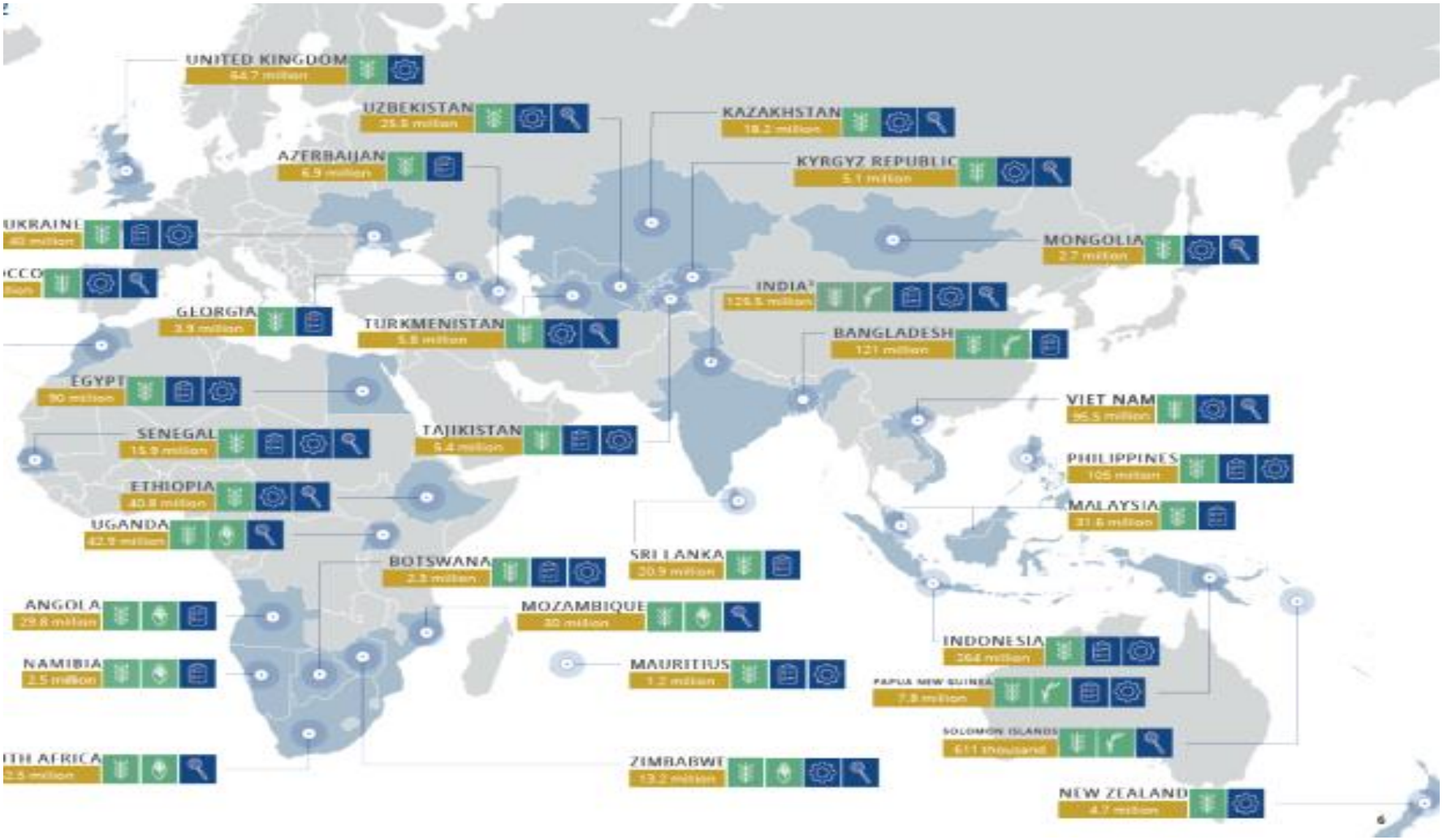


Fig 2.14: Reach of Fortified Foods across the world

Table 2.5: Food Fortification around the World

S.no	Country	Progress by FFI	Organizations working Together
1	AFRICA	‘ Smarter Future’ is the program running in Africa that has been running for the last 15 years and has conducted 27 meetings for the stakeholders and provided technical support to government officials, producers, manufacturers, and organizations in 26 countries. Smarter Future has reached 723 million people through the implementation of mandatory food Fortification of grain (Wheat flour Maize, Rice) in 29 countries, as of December 2021. The initiative has prevented 21 million cases of anemia amongst WRA and 43k cases of neural tube defects by providing Fortified grains to the people	1. Global Alliance for Improved Nutrition 2. International Federation for Spina Bifida and Hydrocephalus 3. Buhler 4. Hellen Keller international Muhlenchemie 5. Nouryon 6. Nutrition International 7. World Food Programme 8. Ministry of Foreign Affairs of the Netherlands

2	EGYPT	FFI conducted Flour Fortification advocacy workshops in Egypt for millers, along with various stakeholders from the private and public sectors. The recent workshop was conducted on 21st April 2021 which demonstrated the process of Fortification and its significance concerning reduction in anemia and neural tube defect cases amongst children. Wheat flour is the main vehicle of Fortification in Egypt since its consumption is 17 million tons annually. Baladi bread which is made of wheat flour is widely consumed in EGYPT, through safety net programs and open markets, the Fortification of wheat will enable 90% of the population to receive the benefits of vitamins and micronutrients added to it.	1. Ministry of Supply and Internal Trade 2. Ministry of Health, National Nutrition Institute 3. National Food Safety Authority 4. The Food Holding Company 5. The American Chamber of Commerce 6. MOSIT, FCI, UNICEF, GAIN, USAID and 7. International Federation of Spina Bifida and Hydrocephalus

3	UGANDA	In Uganda, the food Fortification initiative was undertaken for wheat flour, Maize flour, and oil. Uganda faced a tremendous shortage of food during the hit of the covid wave, however, the workshops made all producers of wheat, 90% of oil producers, and 6% of maize producers, Fortify their products according to national standards. The implementation of daily premix reconciliation helped in overcoming the challenges of distancing, and shortage of workforce during covid. The potential reach of Fortified food was 42.9 Million people in the country.	
4	New Zealand	New Zealand mandated the Fortification of wheat flour with folic acid which has benefitted 5 million people. FFI has helped in growing political support in NZ and Australia and has connected public and private industrialists. The Australian Fortification strategy has led to a decrease in Neural Tube Defects by 14.4% since 2009. The potential reach is 4.7 million people in the country.	

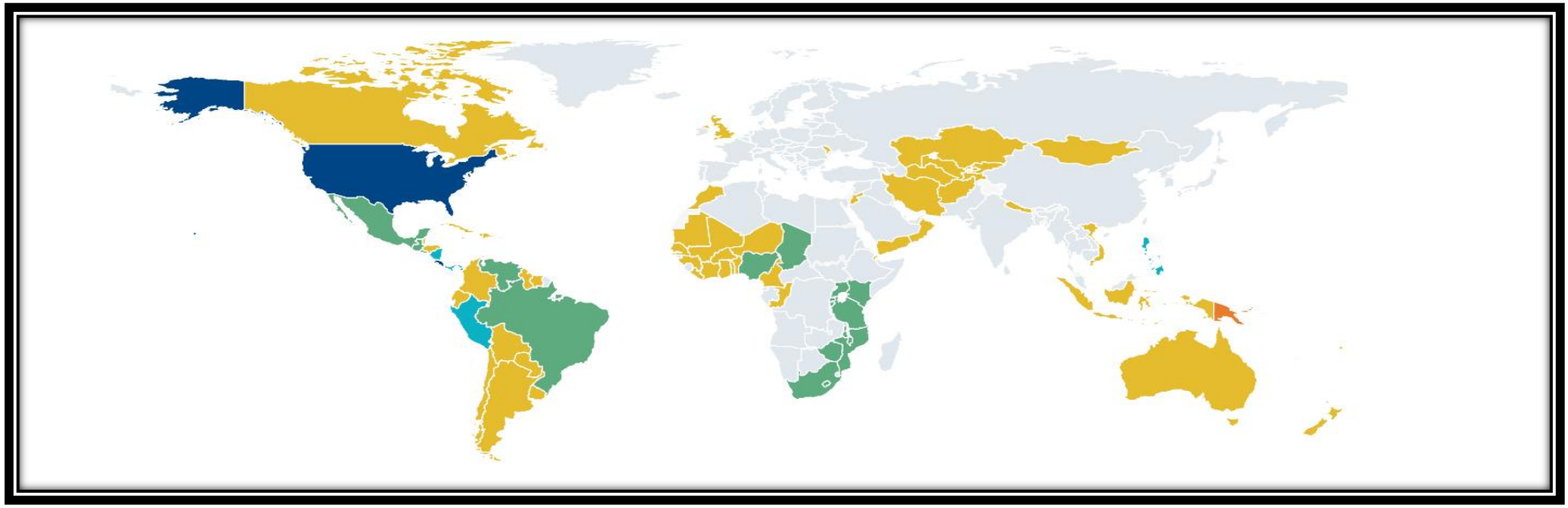
5	Solomon Island	Fortification started on Soloman Island in 2015. FFI built a robust program and technical support for wheat flour and rice. FFI is creating a sustainable, impactful strategy for the program. The Major success of the FFI initiative was intense training and providing technical support to the ministry and training for the regular inspection of Fortification of wheat flour and rice. A high compliance rate was observed for both producers and importers according to the national standards. The quarterly report of MHMS states that there was 100% compliance with spot testing at ports and certificate checks for all the Fortified rice received.	1. Australian Department of Foreign Affairs (DFAT) 2. Ministry of Health and Medical Services (MHMS) 3. Customs and Biosecurity
6	Ukraine	A deputy of Ukraine Parliament, OMNI NET Ukraine Birth Defects Monitoring Program submitted a draft for wheat flour Fortification on 16th June 2021. FFI gave their inputs for holistic Fortification in the grains and provide technical assistance. FFI has been helping in planning, implementation, and monitoring, however, due to political instability, FFI workshops and contributions have been hampered.	1. OMNI NET Ukraine Birth Defects Monitoring Program 2. Ivan Mirashnichenko, a former Ukrainian Government official 3. Olga Trigub, leader of Business-Guard, a nongovernmental

7	United Kingdom	The UK mandated wheat flour Fortification in 1940. However, in 2021, Fortification with folic acid has been updated in the standards. Since 2013 FFI has been conducting advocacy sessions with government agencies on Fortification with folic acid for overcoming neural tube defect cases in the country and participated in 2019 in public consultation with various other key stakeholders, which resulted in support from stakeholders who agreed to the Fortification. Finally, the UK has made wheat flour Fortification with folic acid a mandate.	1. Queen's Nursing Institute - Scotland, 2. International Federation for Spina Bifida and Hydrocephalus, and Shine, a UK

8	India	The potential reach in India is 125.5. million people. The Multi-Sectoral group formed by FFI has provided scientific based evidence for Fortifying wheat flour and revising the national standards for Fortification. BDPTF and FFI conducted various meetings with government officials and made a momentum for Fortification to be adopted as the strategy to be adopted for overcoming micronutrient deficiency and which suits the Indian context. IN 2022 BDPTF will be conducting media workshops for the involvement of media with their scientific panel on changing the standards.	1. Food Safety and Standards Authority of India (FSSAI 2. World Health Organization 3. Spina Bifida Foundation 4. Health Minister, 5. Minister of Women and Child Development, and 6. Minister of Social Justice and Empowerment

Source: (FFI., 2021a)

Global Food Fortification exchange creates analysis and provides visualization of data across the world. The data covers 196 countries in total and provides information for different Fortificants and staples in these countries and their status



	Wheat flour alone – 64 countries		**Wheat flour and rice – 5 countries (Nicaragua, Panama, Peru, Philippines, Solomon Islands)**
	Rice alone – 1 country (Papua New Guinea)		**Wheat flour, maize flour, and rice – 2 countries (Costa Rica and the United States)**
	Wheat flour and maize flour – 17 countries		**No mandatory Fortification legislation or data not available**

Fig 2.15: Status of Fortification of Wheat Flour and Rice in 91 Countries

Source: https://www.ffinetwork.org/globalprogress October 2021.

In India, Haryana has been Fortifying Wheat Flour even during the hit of the COVID 19 wave in 22 districts of Haryana which is being supplied through the Mid-Day Meals and Integrated Child Development Scheme (ICDS). With the support of FFI, state cooperatives of Haryana having control of the market and supply federation are conducting advocacy sessions with 50 millers to meet the demands (FFI., 2021b). Recently in India, the union cabinet decided to distribute Fortified rice of 37.5 mt till March 2024 through government programs like ICDS and MDM, for which FCI has procured 88.65 Mt of Fortified rice which has cost approx. 270 crores /per annum which will be borne by the center under the subsidy bill (Mukherjee., 2021).

2.9 Fortification and Way Forward

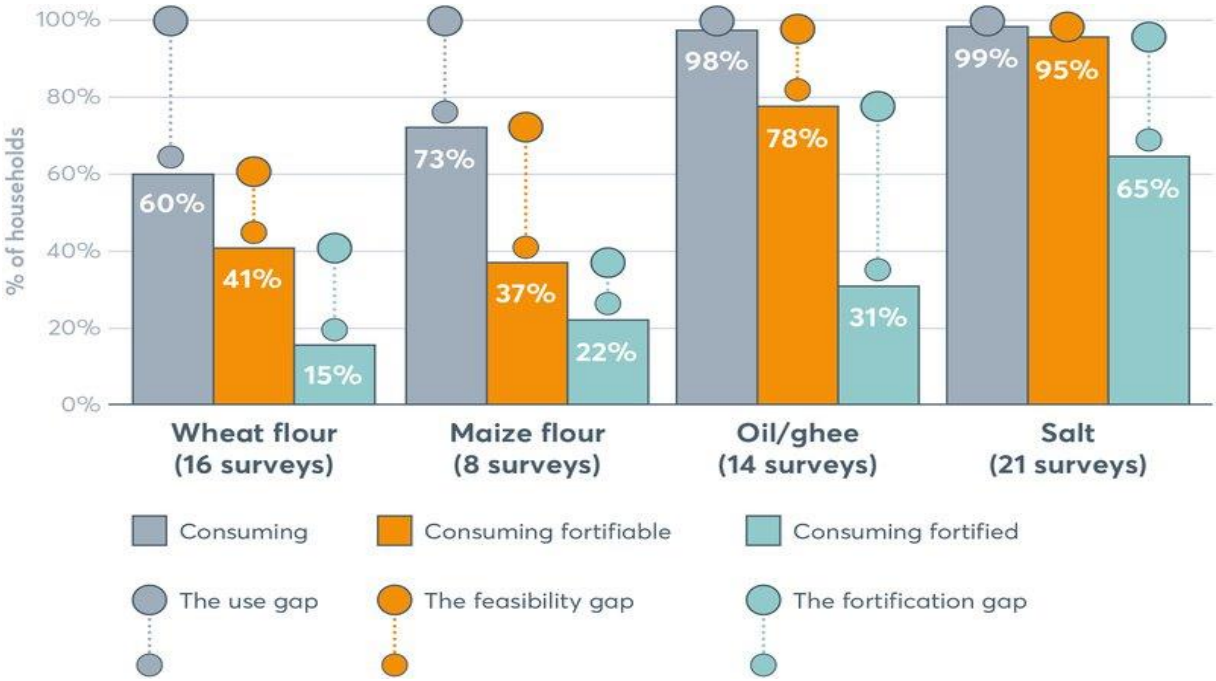


Fig 2.16: Global Status of Fortification (Keats, 2019)

The FACT sheet developed by GAIN has been used to collect information on the consumption of Fortified Foods from 16 countries and to assess the coverage of Fortified Foods from 2013 to 2017. The image represents the gap in the usage, feasibility, and the Fortification gap amongst the selected households. The results will help in monitoring and evaluating the Fortification according to the standards (Keats., 2019).

India has achieved a lot with its Food Fortification Programme. Various pilot schemes are being organized for the distribution of rice under PDS, ICDS, and MDM systems worth INR 174

crores (Approx) with the support of the Ministry of Women and Child Development and Ministry of Human Resource Development.

There are multiple programs and celebrations organized in schools and for the public for awareness with the support of FSSAI. A separate section has been added by Amazon India for Fortified Foods which creates a sensitization amongst the consumers through its +F logo.

National Ear Right Day is celebrated during December, Swasth Bharat yatra, Project Dhoop by TINI, Seminars on Fortification for stakeholders, coverage of Fortified milk on DD national by Tata Trust, and Endorsement of Fortified Foods in Vistara Airlines are few of the initiative taken by FFRC and FSSAI for creating the awareness for the Fortified Foods (Teaotia and Singhal., 2020).