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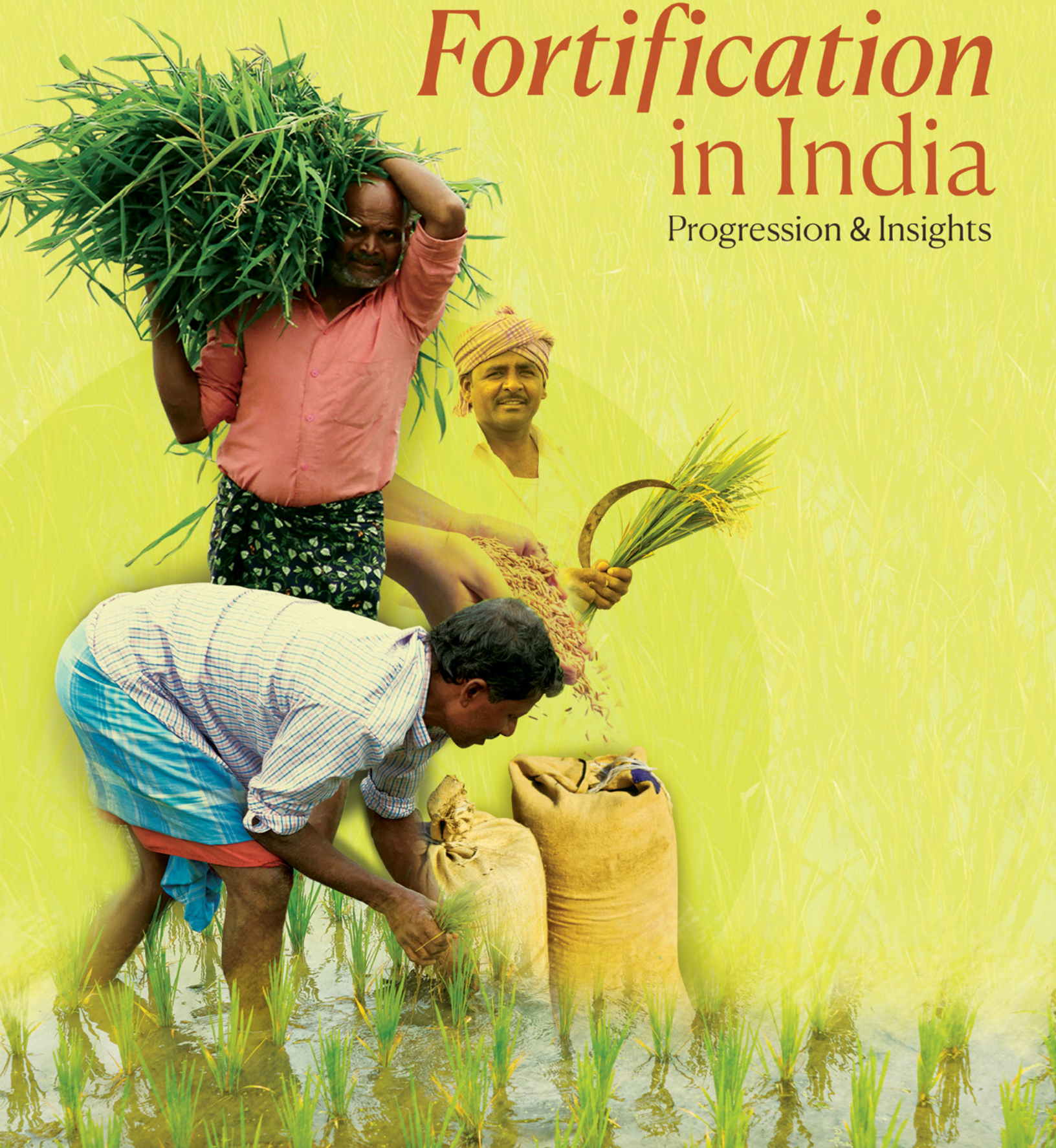
Rice *Fortification* in India

Progression & Insights



Rice Fortification in India:

Progression and Insights

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Foreword

Food security and nutrition have always been a key priority agenda for India. Within the Indian food basket, rice holds a central place, making rice fortification a significant endeavor. It is with great pleasure that I introduce this review on rice fortification program in India. To fulfil the Hon'ble Prime Minister's vision of a nutrition and food secure nation, this subject is of immense significance. With our diverse and significant population, intwined with complex and varied dietary habits, accessibility and lack of affordability, the government's decision to cater to 800 million most vulnerable people shows promise and continues to align with our commitment to achieving the Sustainable Development Goals (SDGs) and the objectives set by the G20.

Our rice fortification strategy employs a multi-faceted approach that combines coherent and effective short, medium, and long-term responses to address the multifaceted challenge of food security and nutrition.This review offers a thorough examination of the various aspects of rice fortification in India, underpinned by rigorous research and informed analysis. It analyzes the governmental and regulatory frameworks, comprehensively examines the financial variables, and explores the ethical implications of the program while also looking at its scientific and nutritional components of the program. Together, these insights provide a comprehensive understanding of the complexities inherent in rice fortification in India, benefiting policymakers, public health experts, and the business community.

The authors, researchers, and subject matter experts who devoted their time and knowledge to synthesizing this review merit my deepest gratitude. They have demonstrated a great dedication to increasing our awareness of the benefits of rice fortification, and their efforts have the potential to significantly improve the lives of millions in India. I would like to offer special commendations the Food Safety and Standards Authority of India for pioneering this effect and applaud the Department of Food and Public Distribution for undertaking the monumental task of implementing rice fortification.

In my role as a bureaucrat entrusted with developing policies and overseeing governance within the G20, I understand the critical importance of well-informed decision-making in realizing the potential of fortified rice. Food security and nutrition are also an important issue not only for India but also to countries in the Global South. As the voice of the Global South, India's approach is to articulate solutions that are beneficial to the developing countries. We are steadfast in our approach, encapsulated in the motto of our G20 Presidency: "One Earth, One Family, One Future." Our commitment extends to assisting vulnerable countries, particularly Net Food Importing Developing Countries (NFIDCs), in achieving food security and nutrition, thereby contributing to our global commitment to SDG 2, aimed at ending hunger and achieving food and nutrition security.

This report is also an affirmation of our commitment to enhance global food security and nutrition for all in line with the G20 Deccan High-Level Principles, which was adopted during the G20 Agriculture Ministers Meeting at Hyderabad. I hope the review will also provide insights to other developing countries to learn from India experience in large scale rice fortification and complement their efforts to enhance the availability and accessibility of nutritious food while strengthening food safety nets. Therefore, I earnestly hope that this assessment, conducted by Dr Richard Dasher and Dr. Amit Kapoor,will serve as an invaluable tool for policymakers, civil society organizations, and other stakeholders committed to sharing India's rice fortification on the global stage.

In conclusion, India is poised to become a global leader in rice fortification, owing to the collaborative efforts of numerous stakeholders who have championed evidence-based decision-making and fostered cooperative relationships across sectors. Together, we work towards a future where nutritious food is accessible to all.

Warm Regards

Yours sincerely,

(Amitabh Kant)

Place- New Delhi
Dated- 06/10/2023

वसुधैव कुटुम्बकम्
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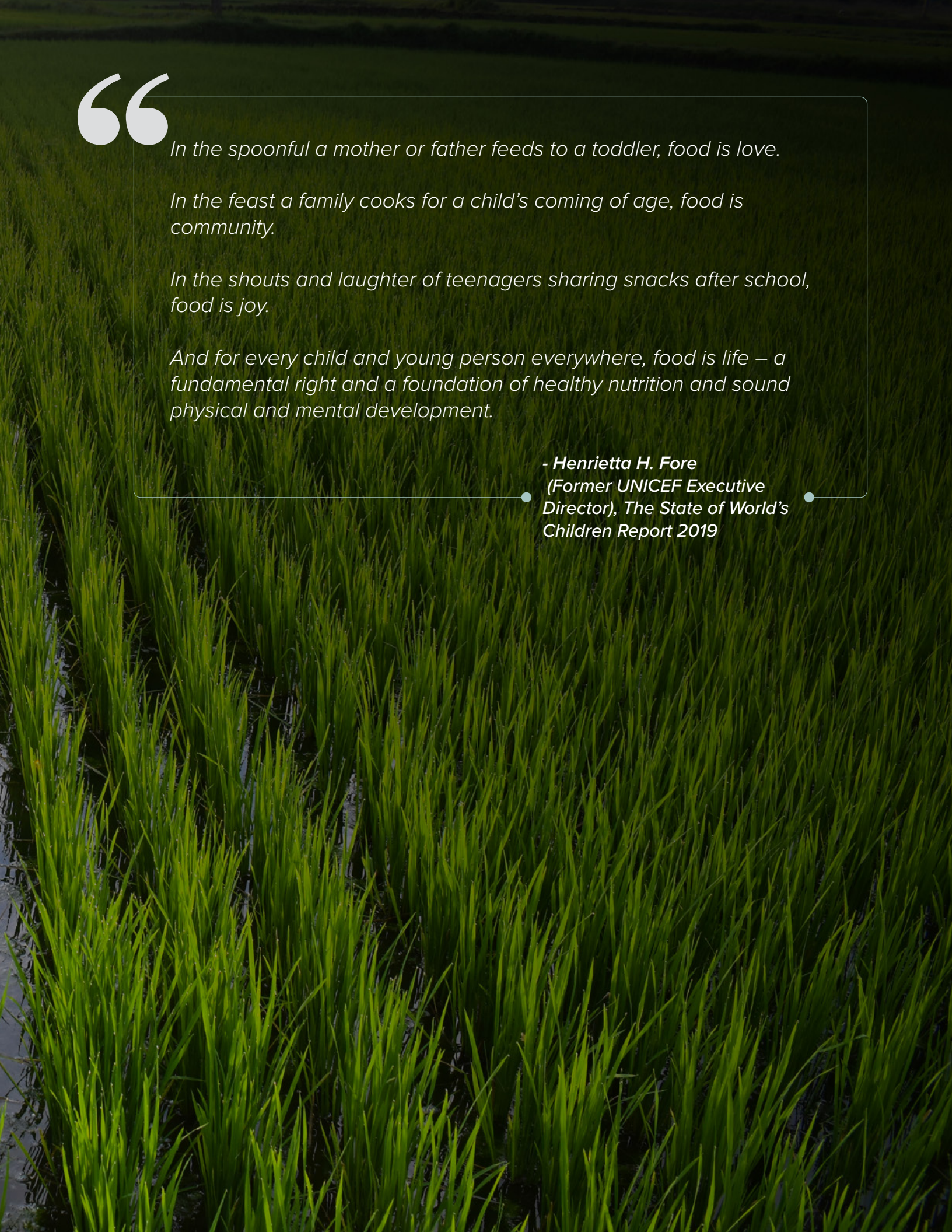


In the spoonful a mother or father feeds to a toddler, food is love.

In the feast a family cooks for a child's coming of age, food is community.

In the shouts and laughter of teenagers sharing snacks after school, food is joy.

And for every child and young person everywhere, food is life – a fundamental right and a foundation of healthy nutrition and sound physical and mental development.

- Henrietta H. Fore
(Former UNICEF Executive Director), The State of World's Children Report 2019

01 Executive Summary

This paper offers an in-depth exploration of Rice Fortification in India, underscoring its vital role in mitigating malnutrition and addressing hidden hunger. It underscores the significance of widespread food fortification initiatives in India, with a specific focus on rice fortification. Despite notable advancements, malnutrition remains a pressing issue in the country, necessitating concerted efforts from various stakeholders, including governmental ministries, subject matter experts, and the food industry, to combat this challenge at a national scale.

Post-2019, India introduced a pilot program followed by a mandate for rice fortification within major social assistance programs. The paper underscores the multifaceted advantages of rice fortification, encompassing enhanced nutritional well-being, reduced susceptibility to chronic ailments, and heightened economic productivity. Paramount research substantiates the favourable impacts of rice fortification, such as elevated iron levels, increased haemoglobin levels, and enhanced cognitive development.

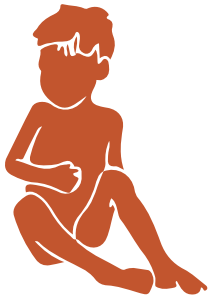
Furthermore, the paper draws attention to the obstacles faced by certain demographics, notably women, children, and young individuals, in obtaining access to a balanced, nutritious diet. This concern is particularly pertinent in India, where one-third of the population comprises of youth. The paper stresses the imperative of heightening awareness to ensure widespread availability of nutritious food for holistic health enhancement.

This paper illuminates the advancements and discernments gleaned from the implementation of rice fortification in India to combat hidden hunger. India's experience with large-scale food fortification initiatives is longstanding, dating back 73 years to the initiation of its salt fortification program to counteract goitre. The paper underscores the ongoing endeavours to guarantee universal access to wholesome nutrition for comprehensive and robust development.

The Spectre of Hidden Hunger

Malnutrition is a distressing condition that affects millions of people worldwide, with severe consequences on physical, mental, and emotional health. Physically, malnutrition can lead to stunting, wasting, and micronutrient deficiencies, hindering growth and development, impairing learning abilities, and impacting productivity. Mentally, malnutrition can cause depression, anxiety, and cognitive impairment, affecting social interactions and problem-solving abilities. Emotionally, it may lead to feelings of shame, isolation, and hopelessness, making it challenging for individuals to cope with daily challenges and thrive in their communities.

Malnutrition extends beyond mere hunger and affects every country worldwide, presenting one of the greatest global health challenges. It encompasses diverse conditions, including undernutrition (wasting, stunting, underweight), deficiencies in essential vitamins and minerals, overweight, obesity, and diet-related noncommunicable diseases (NCDs). (Branca, 2017)



Globally, overcoming malnutrition remains a significant challenge. The SDGs which were set by the 65th World Health Assembly (WHA) in May 2012 to combat malnutrition worldwide emphasized five key indicators to assess the nutrition status in countries: the prevalence of stunting, wasting, and overweight in children under five, the percentage of infants exclusively breastfed before six months, and the percentage of women (aged 15-49) with anaemia.

Hidden hunger, a form of malnutrition that arises from insufficient intake and absorption of vital vitamins and minerals like zinc, iodine, and iron, hindering proper health and growth, remains a significant public health concern in Low Middle-Income Countries (LMICs) (refer BOX 1). It has been estimated to lead to annual gross domestic product losses of 2% to 5%, amounting to approximately US$20 to US$30 billion, despite ongoing efforts to combat it. (Osendarp, et al., 2018).

As of 2021,

approximately 2.3 billion people, accounting for nearly

29.3% OF THE GLOBAL POPULATION,

experienced moderate to severe food insecurity, marking an increase from 25.4% before the pandemic (2022 Global Nutrition Report, 2022).

Children and pregnant women in LMICs are at significant risk due to micronutrient deficiencies, with an estimated 155 million children under 5 years suffering from stunting in 2016. Tragically, around 45% of deaths among children under 5 are attributed to undernutrition. Furthermore, in 2020, 149 million children under 5 were stunted, 45 million were wasted, and 38.9 million were overweight or obese on a global scale. (Branca, 2017)

Iodine, vitamin A, and iron deficiencies pose substantial threats to health and development, especially among children and pregnant women in low-income countries. Unhealthy diets and poor nutrition are leading risk factors for cardiovascular diseases, specific cancers, and diabetes worldwide (Branca, 2017). One of the most pressing yet often overlooked concerns is anaemia, particularly among women. Anaemia not only impacts the health and well-being of women but also elevates the risk of adverse maternal and neonatal outcomes, perpetuating a cycle of malnutrition across generations.

BOX 1

How are countries grouped on basis of Income (per capita)?

The World Bank classifies economies (or countries) into four groups based on gross national income (GNI) per capita.

The classifications and thresholds for the 2024 fiscal year, using data from 2022 are:

- **Low-income economies:** GNI per capita of $1,135 or less. (Afghanistan, Madagascar, Ethiopia, etc.)
- **Lower middle-income economies (LMICs):** GNI per capita between $1,136 and $4,465. (Myanmar, Zimbabwe, India, etc.)
- **Upper middle-income economies:** GNI per capita between $4,466 and $13,845. (Mexico, Malaysia, South Africa, etc.)
- **High-income economies:** GNI per capita of $13,846 or more. (UAE, UK, US, Taiwan, etc.)

The global nutrition crisis, which was already of great concern before the Covid-19 outbreak, has worsened significantly.

The number of people affected by hunger surged by

150Mn since 2019,

reaching

768Mn in 2021

Moreover, those unable to afford a healthy diet increased by 112 million, totalling 3.1 billion in 2020 alone. (2022 Global Nutrition Report, 2022).

Thinking Global: The importance of nutrition in SDGs

In 2015, leaders from around the world gathered in New York to agree on a set of 17 goals and 169 targets. These were aimed at solving the social, economic, and environmental problems facing the world. This comprehensive plan for action is known as the Sustainable Development Goals (SDGs). It took over from the Millennium Development Goals (MDGs), which came to an end that year.

The SDGs are built upon more than a decade of efforts from participating countries. Essentially, they represent a continuation of the eight Millennium Development Goals (MDGs), which started in 2000 and concluded in 2015. The MDGs were instrumental in lifting nearly one billion people out of extreme poverty, fighting hunger, and increasing access to education, particularly for girls. Additionally, they significantly contributed to safeguarding our planet. This was achieved by all but eliminating global consumption of substances harmful to the ozone layer, reforestation efforts, and expanding protected land and coastal marine areas worldwide.

The SDGs aim to sustain the progress generated by the MDGs. They outline an ambitious development agenda for the years after 2015. This initiative would require an investment of over $4 trillion annually globally. The SDGs were a direct outcome of the 2012 Rio+20 Earth Summit. This summit called for the establishment of an open working group to devise a draft agenda for the years beyond 2015.

In contrast to the MDGs, which mainly relied on funding from governments and non-profit organizations, the SDGs look to the private business sector for contributions. This involvement is crucial in transforming impractical and unsustainable consumption and production patterns.

Nutrition: Recognizing the significance of enhanced nutrition, SDG 2 stands as a cornerstone, striving not only to eliminate hunger but also to ensure food security and promote sustainable agriculture.

However, the endeavour to improve nutrition transcends the boundaries of SDG 2. Its success is intricately tied to the realization of every SDG, forming the very foundation of sustainable global development. Resolving malnutrition holds the potential to trigger profound improvements in health and contribute significantly to the fight against poverty. Therefore, advancing in the realm of nutrition is not just desirable but essential for making substantial strides in sustainable development.

The impact of nutrition extends directly to seven SDGs, with its influence echoing in various dimensions. Beyond doubt, it directly shapes the outcomes of SDGs 2 and 3, and its indirect effects resonate in the realms of SDGs 1, 4, 5, 6, and 8. These interconnections underscore the intricate tapestry that links nutrition with the broader landscape of global development.

(Romana, Grieg, Thompson, & Arabi, 2021)

SDG 2:

"End hunger, achieve food security, and improve nutrition" is affected by malnutrition due to its impact on sustainable agriculture and food security.

SDG 3:

“Ensure healthy lives and promote well-being for all at all ages” is affected due to the increased risk of infections and diseases caused by malnutrition.

SDG 1:

“No Poverty” is indirectly affected as malnutrition decreases earning capacity, increasing the risk of poverty.

SDG 4:

“Quality Education” is indirectly affected as malnutrition hinders development potential, impacting access to quality education.

SDG 5:

“Gender Equality” is indirectly affected as empowering women to claim their rights improves nutrition and quality of life, leading to better education and job opportunities.

SDG 6:

“Clean Water and Sanitation” is indirectly affected by malnutrition’s broader impact on public health and well-being.

SDG 8:

“Decent Work and Economic Growth” is indirectly impacted as proper nutrition improves learning performance, translating into better job opportunities.

The interconnection between malnutrition and achieving the SDG goals highlights the pivotal role of nutrition in their attainment. It is imperative to address malnutrition in all its forms, given its profound impact on global health and well-being.

Despite the considerable attention given to malnutrition in the Sustainable Development Goals (SDG) 2030 Agenda, it remains a persistent challenge on a global scale. The SDGs rightly recognize that nutrition is intricately linked with numerous developmental objectives. Therefore, the attainment of Target 2.2 within the SDGs holds paramount importance.

This target aims to eradicate all forms of malnutrition by 2030. This includes meeting the internationally agreed-upon targets concerning stunting and wasting in children under five years of age by 2025. Additionally, it encompasses addressing the nutritional requirements of adolescent girls, pregnant and lactating women, as well as older individuals. This concerted effort is essential in ensuring a healthier and more prosperous global community.

Despite some advancements, the progress towards achieving the Sustainable Development Goals (SDGs) is not occurring at the necessary pace or with the required momentum to meet the 2030 deadline. In terms of poverty alleviation, there have been only marginal improvements.

According to the 2018 SDGs Report

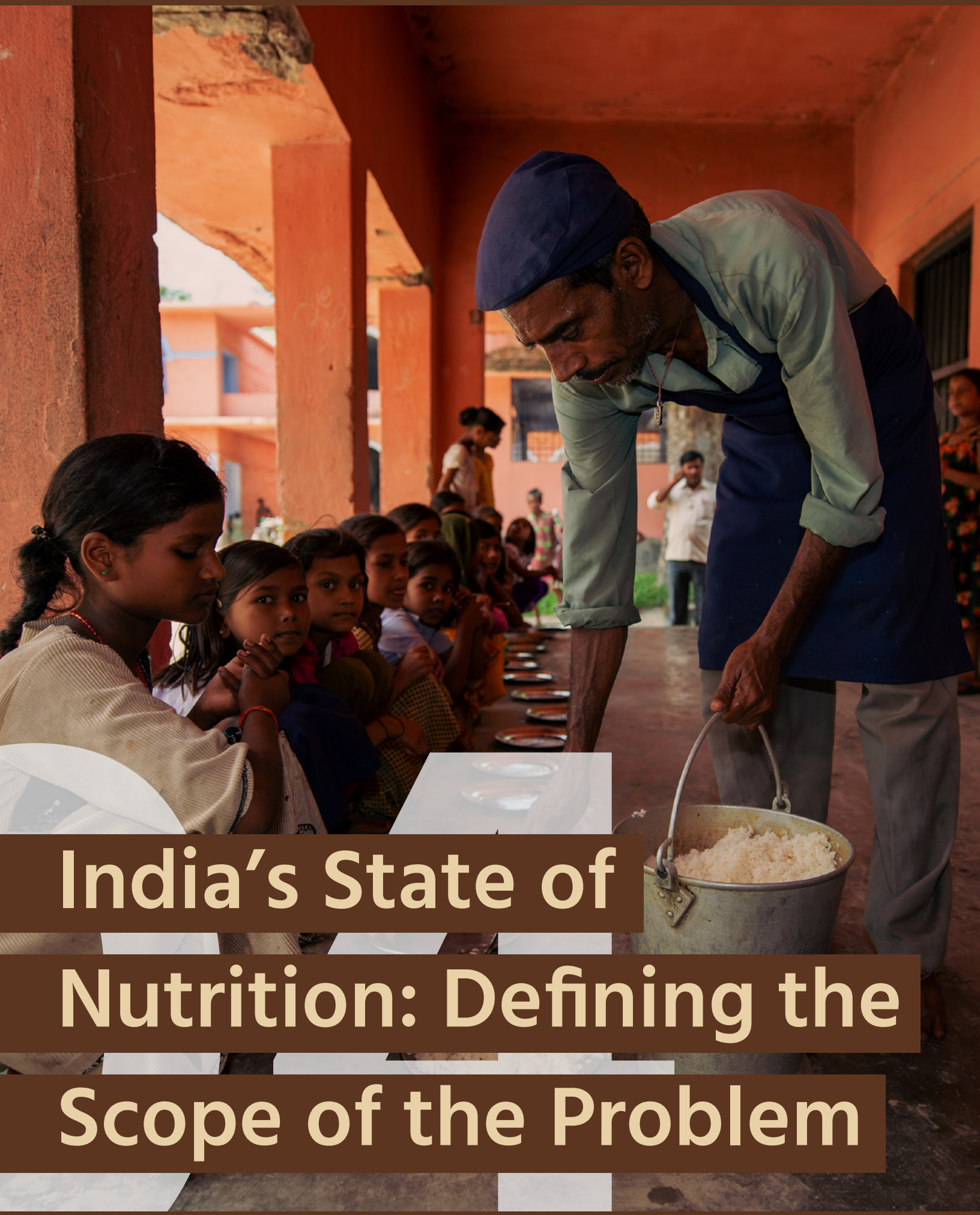
approximately **9.2%** **of the global workforce,** living with their families, earned less than $1.90 per person per day in 2017. This reflects a less than 1 % improvement from 2015.

Moreover, there has been a recent resurgence in world hunger. While hunger rates had been on a steady decline,

the 2018 SDGs Report revealed that in 2016, over

800Mn people experienced undernourishment globally.

This marked an increase from the 777 million individuals reported in 2015. This underscores the pressing need for accelerated efforts to achieve the SDGs and address these critical global challenges.



India's State of Nutrition: Defining the Scope of the Problem

A reduction in malnutrition levels in a population would require a multi-pronged approach rather than a single approach as global experiences have shown. Within the realm of malnutrition, micronutrient deficiency induced malnutrition is of specific concern. Micronutrients are vitamin and minerals which, are required in relatively much smaller amount than, for example, protein or carbohydrates. Still, they are the buildings blocks for good health and overall well-being.

Micronutrients are indispensable in helping foetuses, infants, and children grow and thrive. They help in avoiding serious birth defects, undeveloped cognitive ability, maternal and infant deaths, childhood blindness and reduction in productivity. Normally, humans cannot produce micronutrients inside their bodies except vitamin D (although the ability of human body to absorb vitamin D is dependent on several other micronutrients especially calcium and zinc). As a result, over the course of history, humans have strived to consume as much varied diet as possible in order to ingest as many micronutrients as possible in good enough amounts. Yet, micronutrients are found lacking in large part of populations all over the globe including India.

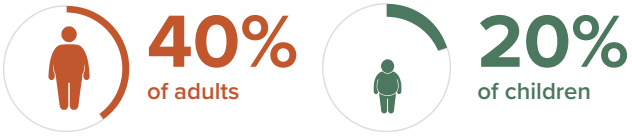
TABLE 1: An estimate of the overall prevalence of micronutrient deficiencies in India

Micronutrient	Prevalence
Vitamin D deficiency	61%
Iron deficiency	54%
Vitamin B12 deficiency	54%
Folic acid deficiency	37%
Vitamin A deficiency	19%
Iodine deficiency	17%

Pooled prevalence from children (0–5 years), adolescents (<18 years), adults (>18 years) and pregnant women.
Source: (Venkatesh, et al., 2021)

Thus, micronutrients need to be a part of everyday diet because they can only be consumed from external sources. However, the global diet continues to fall short of the minimum standards for healthy and sustainable eating, leading to a rise in obesity and diet-related non-communicable diseases (NCDs).

Percentage of overweight or obese people as per Global Nutrition Report 2022



Despite existing policy interventions[1] , these trends remain unaltered, and factors such as ongoing conflicts worldwide, including recent events like the war in Ukraine, and the impacts of climate change, contribute to the escalating rates of malnutrition. This poses a significant threat to countries facing food and nutrition insecurity, especially vulnerable populations. (2022 Global Nutrition Report, 2022)

[1] An existing mechanism, for example, is the collaboration between Centre for Disease Control (CDC), USA with International Micronutrient Malnutrition Prevention and Control (IMMPaCt) program which focuses ondeficiencies of iron, vitamin A, iodine, folate, zinc, and vitamin D and works on micronutrient surveillance and research to fill critical data gaps.

A look at some key papers

Social Progress Index and Aspirational Districts Programme (ADP):

In India, as per SPI[2] 2022 on average,

only 12.32% of children aged 6-23 months receive an adequate diet in Aspirational Districts[3] (ADP districts).

Over 690 districts have less than **30%** of children receiving adequate diet

and in 17 districts **50%** of children are stunted

Furthermore, in 12 districts **50%** of the children are underweight

and no district in India is close to achieving the SDG 2030 target of reducing stunted children to 6%.

In the ADP districts, as per SPI 2022, it was observed that anaemia is more common among children than women. The average prevalence of anaemia in women is 61.20%, while in children it is 69.65%. The districts' performance in terms of anaemia among women varies from 26.9% to 81.5%. Out of the 112 ADPs, 93 districts have over 50% of women suffering from anaemia.

Moreover, 67 ADP districts, which constitute over 50% of the total, have less than 12% of children receiving an adequate diet. Additionally, 82 out of 112 ADP districts have more than 30% of underweight children under five years. The challenges of child nutrition and anaemia persist in these regions, emphasizing the need for targeted interventions and improved healthcare strategies to address these issues effectively. Dietary habits also contribute to malnutrition and higher risks of chronic diseases, as India's average daily calorie consumption falls below the recommended 2503 kcal/capita/day (Sharma, Kishore, & Joshi, 2020). Whole grains contribute more to calorie intake, while fruits, vegetables, legumes, meat, fish, and eggs are consumed in lower quantities. Inadequate protein intake is a concern, with only 6-8% of calories coming from protein sources. Additionally, a preference for processed foods over fruits and excessive cereal consumption further compounds the issue (Sharma, Kishore, & Joshi, 2020).

National Family Health Survey (NFHS)[4] :

India's National Family Health Survey 5 (NFHS 5) reveals some positive progress in specific nutritional status indicators, such as BMI and the consumption of iron folic acid supplements among pregnant women (refer to Table 1). However, it is concerning to observe that the incidence of anaemia has actually increased across all segments of society covered by the NFHS questionnaire during the period between NFHS 4 (2015-16) and NFHS 5 (2019-21). This rise in anaemia prevalence is evident among various population groups, including children, pregnant and non-pregnant women, and men (refer to Table 2). Despite improvements in other nutritional measures, this persistent and widespread increase in anaemia cases calls for targeted interventions to address this escalating health concern.

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[2] The Social Progress Index (SPI) is a comprehensive and holistic tool used to measure a country's social progress at both the national and sub-national levels. This index evaluates states and districts by considering 12 components that span three crucial dimensions of social progress.

[3] The Aspirational Districts Programme (ADP) was launched in 2018 to quickly and effectively transform some of the most under-developed districts across the country. These districts under this programme are characterized by poor socio-economic indicators and are ranked based on incremental progress across 49 Key Performance Indicators (KPIs).

[4] NFHS is a comprehensive nationwide survey overseen by the Ministry of Health and Family Welfare, conducted by the International Institute for Population Sciences. It provides essential data on health, family welfare, and related issues. The content of NFHS-5 closely mirrors that of NFHS-4 to enable longitudinal comparisons. However, direct survey comparisons may have slight variations due to differing methodologies and sampling approaches.

TABLE 3: Few select NFHS- 5 indicators depicting nutrition status among Indians

Cohort characteristics	Age and other characteristics	NFHS-5 (2019-21)	NFHS-4 (2015-16)	Percentage change
BMI	Women	18.7	22.9	↓ 18%
	Men	16.2	20.2	↓ 20%
Iron folic consumption among mothers when they were pregnant	for 100 days or more	44.1	30.3	↑ 46%
	for 180 days or more	26	14.4	↑ 81%
Nutritional Status of Children under 5 years	stunted (height-for-age)	35.5	38.4	↓ 8%
	wasted (weight-for-height)	19.3	21	↓ 8%
	underweight (weight-for-age)	32.1	35.8	↓ 10%

SOURCE: NFHS-5 (2019-21)

The high incidence of anaemia in India, as revealed by the National Family Health Survey 5 (NFHS 5), reflects not only a poor diet but also prevalent micronutrient deficiencies. This data emphasizes the need for targeted interventions to address the escalating rates of anaemia in the country and underscores the importance of implementing comprehensive nutrition programs to combat malnutrition in all its forms.

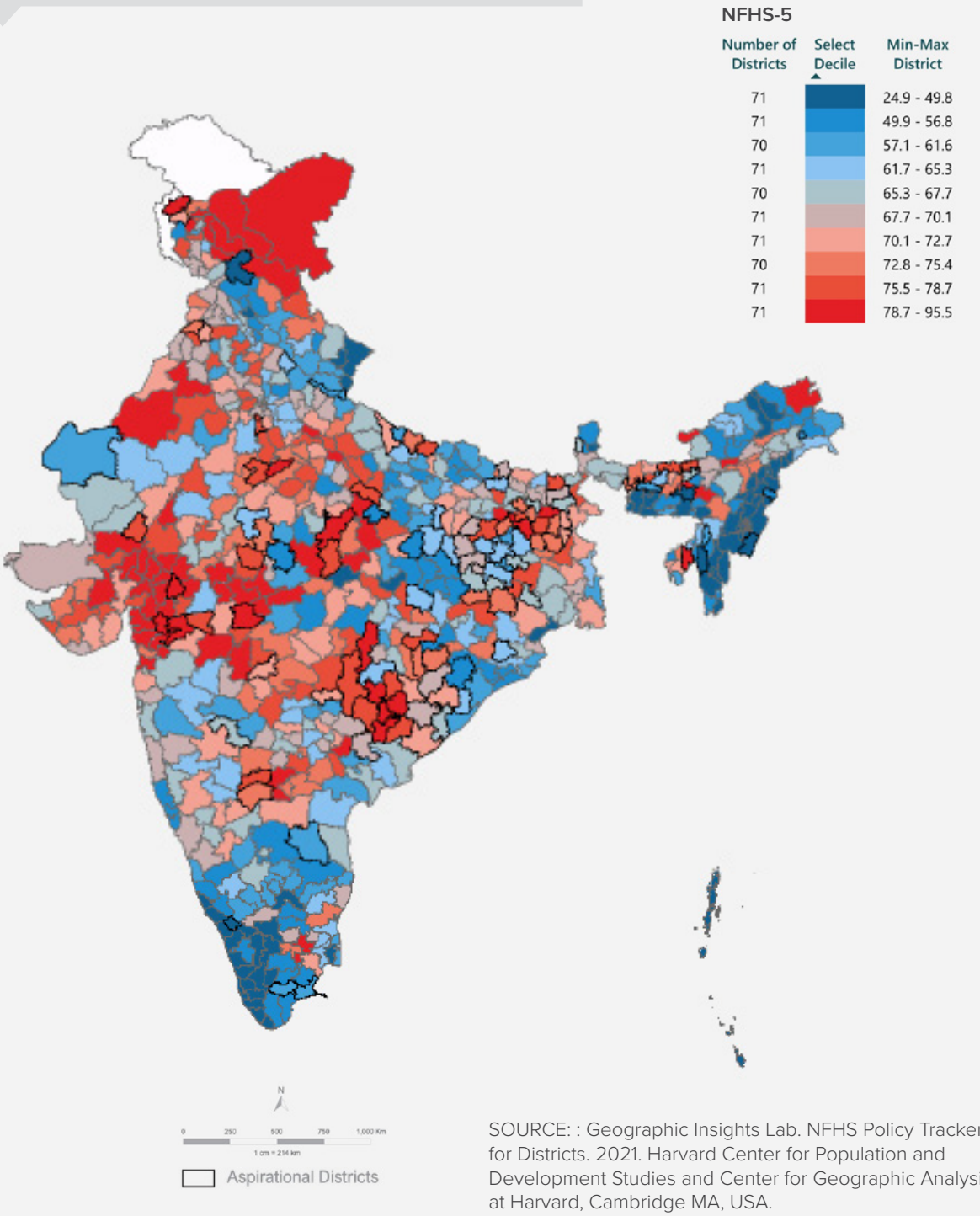
TABLE 4: Prevalence of Anaemia: Select NFHS-5 Indicators

Cohort characteristics	Age and other characteristics	NFHS-5 (2019-21)	NFHS-4 (2015-16)	Percentage change
Children	age **6-59 months**	67.1	58.6	↑ 15%
Women	*Non-pregnant* age **15-49 years**	57.2	53.2	↑ 8%
	Pregnant women age **15-49 years**	52.2	50.4	↑ 4%
	age **15-19 years**	59.1	54.1	↑ 9%
	age **15-49 years**	52.2	50.4	↑ 4%
Men	age **15-19 years**	31.1	29.2	↑ 7%
	age **15-49 years**	25	22.7	↑ 10%

SOURCE: NFHS-5 (2019-21)

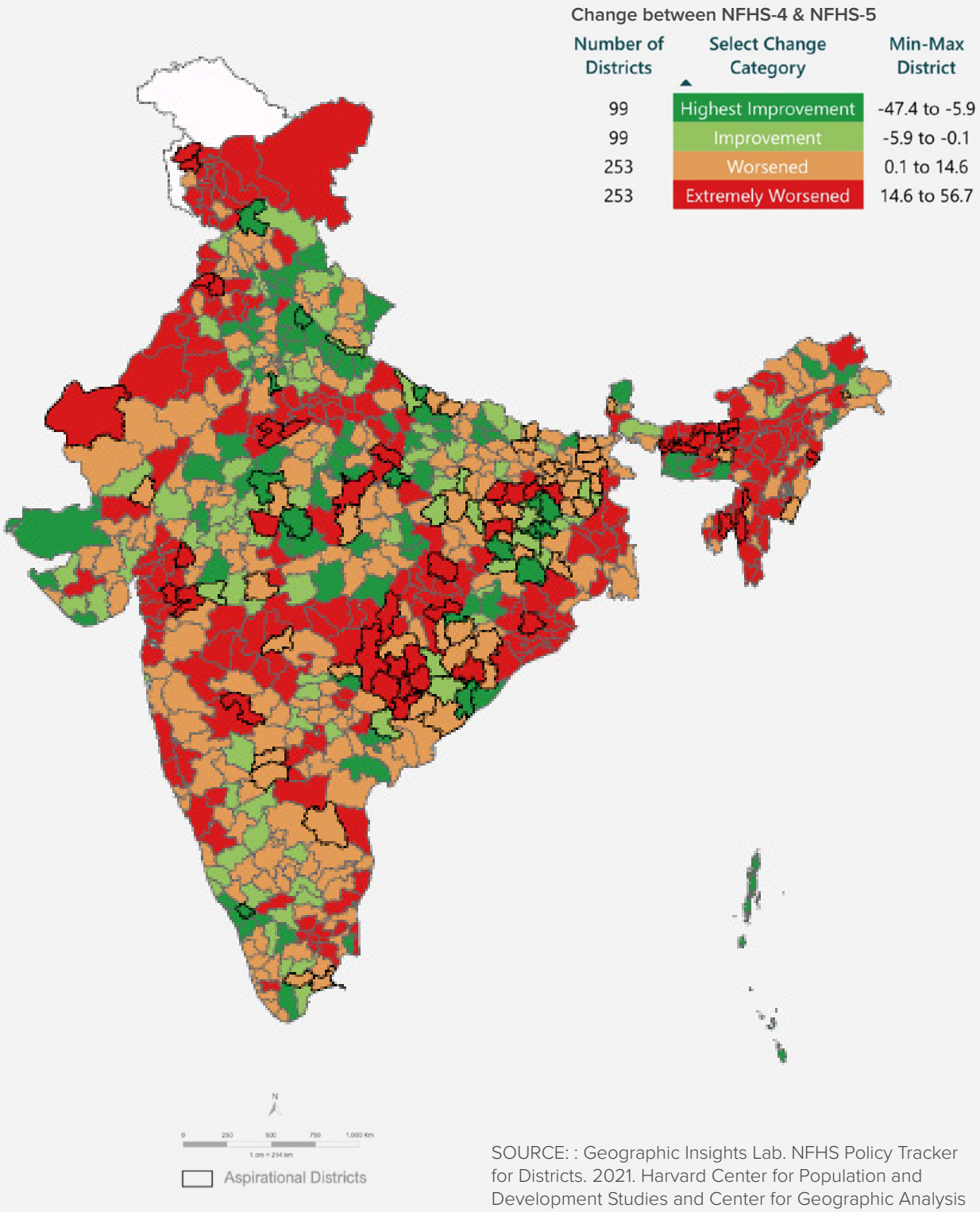
The NFHS Policy Tracker for Districts, developed by the Geographic Insights Lab at the Harvard Center for Population and Development Studies, utilizes district factsheets from the National Family Health Surveys (NFHS-4 and NFHS-5) to present Health, Nutrition, and Population indicators across India. This interactive dashboard allows users to visualize direct estimates of these indicators from NFHS-5 (2019-21) and compare changes between NFHS-4 (2015-16) and NFHS-5.

Prevalence of Anemia among Children as per NFHS-5



SOURCE: : Geographic Insights Lab. NFHS Policy Tracker for Districts. 2021. Harvard Center for Population and Development Studies and Center for Geographic Analysis at Harvard, Cambridge MA, USA.

Changes in Anaemia prevalence among Children between NFHS-4 and NFHS-5

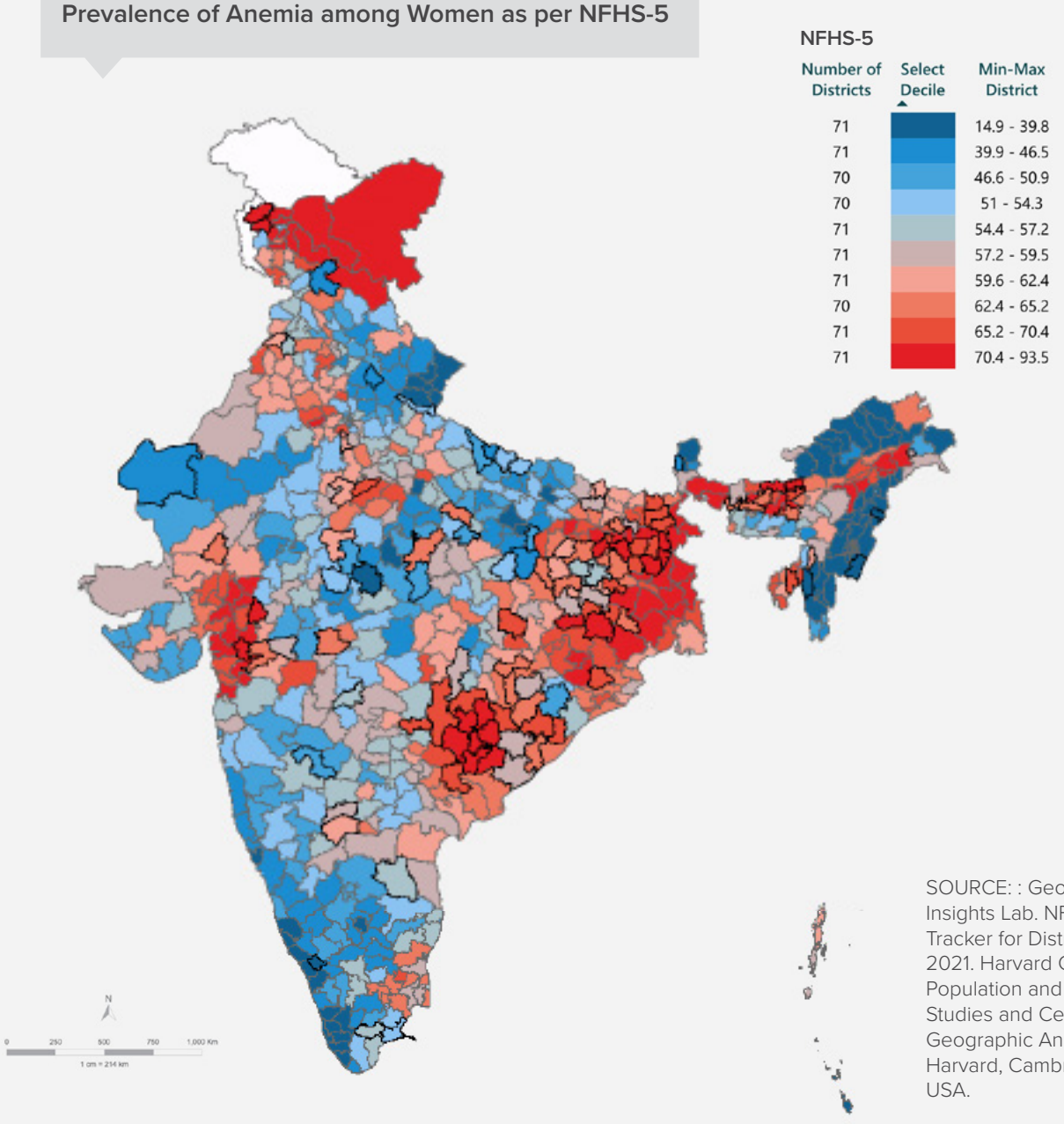


SOURCE: : Geographic Insights Lab. NFHS Policy Tracker for Districts. 2021. Harvard Center for Population and Development Studies and Center for Geographic Analysis at Harvard, Cambridge MA, USA.

The dashboard clearly elucidates that the burden of anaemia among women and children is very high. The highest burden of anaemia is concentrated in certain endemic regions of Bihar, Jharkhand, Gujarat, Uttar Pradesh and Chhattisgarh. There is extremely high burden of anaemia prevalence in Ladakh and selected districts of Jammu and Kashmir require a priority focus for reviewing local dietary factors and supplementation efforts for women and children. The analysis also demonstrates an alarming increase in anaemia rates among both women and children. Nationally, there was a 5% rise in the incidence of anaemia in women, escalating from 51% in NFHS-4 to 56% in NFHS-5. In Aspirational districts, the situation is even more concerning, with a 4.4% surge in anaemia incidence, climbing from 56.8% in NFHS-4 to 61.2% in NFHS-5. (Geographic Insights Lab, 2021)

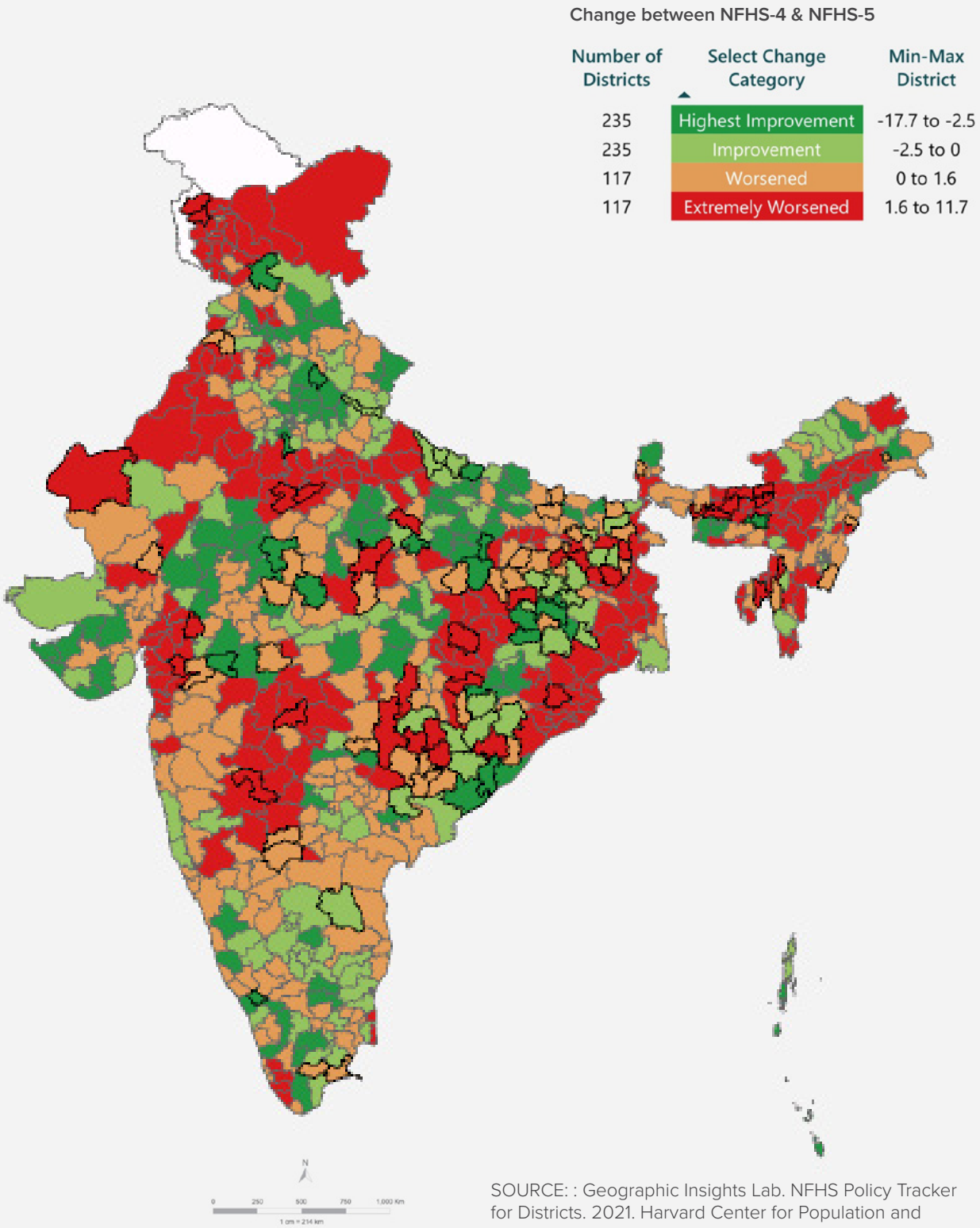
As for children, the overall incidence of anaemia witnessed a substantial 10% escalation, surging from 55.7% in NFHS-4 to 65.9% in NFHS-5. Within Aspirational districts, the situation is equally disconcerting. In NFHS-4, 59.6% of children were found to have anaemia, which surged by 10% in NFHS-5, where 69.7% of children were affected. (Geographic Insights Lab, 2021)

Prevalence of Anemia among Women as per NFHS-5



SOURCE: : Geographic Insights Lab. NFHS Policy Tracker for Districts. 2021. Harvard Center for Population and Development Studies and Center for Geographic Analysis at Harvard, Cambridge MA, USA.

Changes in Anaemia prevalence among Women between NFHS-4 and NFHS-5



SOURCE: : Geographic Insights Lab. NFHS Policy Tracker for Districts. 2021. Harvard Center for Population and Development Studies and Center for Geographic Analysis at Harvard, Cambridge MA, USA.

Comprehensive National Nutrition Survey 2016–2018:

The Ministry of Health conducted the Comprehensive National Nutrition Survey (CNNS) to gather comprehensive data on the nutritional status of Indian children aged 0–19, providing robust insights into both undernutrition and overweight/obesity. This survey stands as the largest global initiative focused on micronutrient assessment. Notably, the CNNS employed internationally recognized methods to evaluate anaemia, micronutrient deficiencies, and non-communicable disease biomarkers, marking a significant milestone in India's healthcare landscape. Early-life stunting bears lasting implications on health, cognitive development, education, and earning potential, underscoring its substantial societal and economic ramifications. A global study highlighted that a mere 1 cm increase in height correlated with a 4% rise in wages for men and 6% for women (McGovern, Krishna, Aguayo, & Subramanian , 2017). Pertaining to dietary practices, while 42% of children aged 6 to 23 months met the recommended meal frequency, only 21% attained dietary diversity, and merely 6% received a minimally acceptable diet. In terms of food consumption among school-age children and adolescents, over 85% included dark green leafy vegetables and pulses or beans in their diet at least once weekly. Approximately one-third incorporated eggs, fish, chicken, or meat into their diet on a weekly basis, and 60% consumed milk or curd at least once weekly. Important findings of the survey were:

1. Vitamin A deficiency is more prevalent in children from poorer households.

Among preschoolers in the poorest households, the prevalence is over double compared to the richest households (27% vs. 11%).

27% Rich VS. **11%** Poor

This trend is also seen in children aged 5–9 years, with 28% prevalence in the poorest households compared to 16% in the richest. However, wealth differences are less pronounced for adolescents. Among adolescents whose mothers had higher education (>12 years of schooling), vitamin A deficiency was lowest at 9%. According to WHO guidelines (2007), vitamin A deficiency is identified as a severe public health problem in 12 states for preschool children and in four states for adolescents.

2. The CNNS found varying prevalence of vitamin D deficiency across different age groups.

Among pre-school children (1–4 years), **14 per cent** were deficient.

For school-age children (5–9 years), the prevalence was **18 per cent.**

Among adolescents (10–19 years), **24 per cent** were deficient

Urban areas showed higher deficiency rates compared to rural areas, and dietary habits also played a role. Additionally, attendance at school influenced the prevalence of vitamin D deficiency. Sikhs consistently exhibited higher rates of deficiency (50% to 72%) compared to scheduled tribes (9% to 15%).

3. Zinc deficiency is a significant concern among children and adolescents in India.

The prevalence of zinc deficiency is as follows:

19%
among pre-school children (1–4 years)

17%
among school-age children (5–9 years)

32%
higher rate among adolescents (10–19 years).

Rural areas show higher prevalence compared to urban areas, and the poorest households are more affected than the wealthiest. Among those attending school, the prevalence is lower than those not in school. Male adolescents are more affected than their female counterparts. The prevalence of zinc deficiency also varies widely across states, ranging from 1% in Nagaland to 41% in Himachal Pradesh among children aged 1–4 years, 2% to 38% among 5–9 years, and 4% to 55% among 10–19 years.

4. Zinc deficiency is a significant concern among children and adolescents in India.

Vitamin B12 deficiency is a concern across different age groups in India.

Among pre-school children (1–4 years), 14% were deficient, while 17% of school-age children (5–9 years) and a higher proportion of 31% of adolescents (10–19 years) showed deficiency. Notable differences were observed among Sikh children aged 5–9 years (25%) and adolescents (51%).

Among pre-school children (1–4 years), **14 per cent** were deficient

while **17 per cent** of school-age children (5–9 years)

and a higher proportion of **31 per cent** of adolescents (10–19 years) showed deficiency

Notable differences were observed among Sikh children aged 5–9 years (25%) and adolescents (51%).

Among adolescents, prevalence differed by sex, with 35% for boys and 27% for girls. Age-wise, 28% and 34% prevalence was observed among adolescents aged 10–14 and 15–19 years, respectively. Regionally, prevalence varied significantly, ranging from 2% in West Bengal to 29% in Gujarat for 1–4 year-olds, from 0% in Nagaland and 1% in Kerala to 31% in Uttar Pradesh and 32% in Punjab for 5–9 year-olds, and from 2% in Kerala and Nagaland to 48% in Gujarat for adolescents aged 10–19 years.

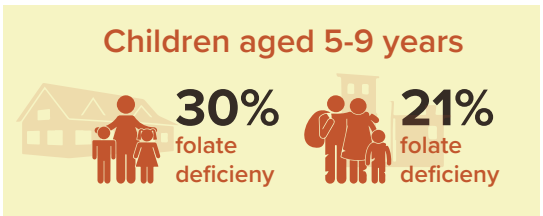
5. Folate deficiency is a concern among children and adolescents in India. Approximately

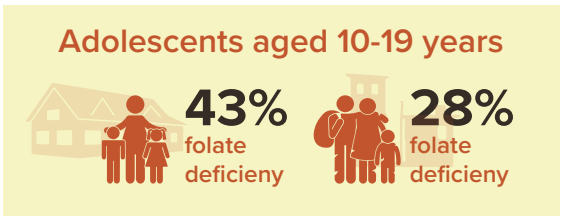
23% of children aged 1–4 years,

28% of those aged 5–9 years

and a higher proportion of **37%** among adolescents aged 10–19 years were found to have folate deficiency

While there was little variability in prevalence among pre-schoolers based on socio-demographic characteristics, notable differences were observed by religion and caste/tribe. Similar patterns were seen in other age groups. **Interestingly, a higher proportion of children aged 5–9 years and adolescents aged 10–19 years from the wealthiest quintile were folate deficient compared to those from the poorest households: 30% vs. 21% among children aged 5–9 years and 43% vs. 28% among adolescents aged 10–19 years.** There was significant state-level variation in the prevalence of folate deficiency.





6. The CNNS findings indicate that children and adolescents in India generally maintain sufficient urinary iodine levels. Specifically, pre-school children had a mUIC of 213 µg/L, school-age children had 175 µg/L, and adolescents had 173 µg/L. With the exception of Tamil Nadu, where mUIC levels exceeded 300 µg/L across all age groups, all other states demonstrated adequate urinary iodine status among both children and adolescents.

TABLE 5: Micronutrient Deficiencies in Indian Children and Adolescents (CNNS 2016–18)

Age Group	Vitamin A Deficiency (%)	Vitamin D Deficiency (%)	Zinc Deficiency (%)	Vitamin B12 Deficiency (%)	Folate Deficiency (%)	Adequate Iodine Status (µg/L) [Suboptimal: mUIC < 50 µg/L]
Pre-school Children (1-4 years)	18	14	19	14	23	213
School-Age Children (5-9 years)	22	18	17	17	28	175
Adolescents (10-19 years)	16	24	32	31	37	173

SOURCE: Comprehensive National Nutrition Survey 2016–2018

India's Changing Trajectory on Food Policy

Historically, India's food policy focused on calorie consumption and achieving food security through self-sufficiency in staple food production. The Green Revolution brought about significant gains in productivity, shifting the focus to ensuring household access to food. This was facilitated through MSP-based procurement from farmers and distribution to low-income consumers via the PDS. However, this approach has faced criticism for not adequately addressing balanced nutrition. Some experts argue that the emphasis on grain self-sufficiency as a means of achieving food security has become outdated. (Pingali, Mittra, & Rahman, 2017)

The Green Revolution (GR) in India, starting in the late 1960s, significantly boosted agricultural productivity, particularly in rice and wheat. This led to increase in per-capita availability of food grains. However, it also shifted focus away from nutrient-rich crops like coarse cereals and pulses. Punjab and Haryana became major producers of staple crops. While the GR improved overall food sufficiency, it didn't adequately address malnutrition or dietary diversity. (Pingali, Mittra, & Rahman, 2017)

Despite a decline in staple prices, nutritious foods like pulses, fruits, and vegetables didn't experience a similar drop. This price difference hindered dietary diversification, especially for the poor. Additionally, the supply of non-staple crops and livestock products didn't grow significantly. Policies from the GR era, which primarily targeted staples, discouraged diversification in food production. The lack of developed markets for non-staples further constrained their growth. Shifting policy focus towards non-staple foods is a crucial challenge for India's food policy. (Pingali, Mittra, & Rahman, 2017)

The Public Distribution System (PDS) is a key part of India's food assistance programs, providing staple foods like rice, wheat, sugar, and kerosene through Fair Price Shops (FPS). While it initially faced challenges, recent improvements have led to a revival of the PDS. It started as an urban food security program during World War II and expanded to rural areas, particularly in states with grain deficits. The PDS primarily supports rice and wheat farmers through procurement at assured prices. (Pingali, Mittra, & Rahman, 2017)

While the PDS has helped address hunger, its impact on nutrition is not entirely clear. Some studies suggest it has increased calorie intake and dietary diversity, while others raise concerns about its effect on diet quality and micronutrient composition. The PDS until recently focused more on calorie adequacy rather than ensuring access to balanced diets. (Pingali, Mittra, & Rahman, 2017)

The Integrated Child Development Scheme (ICDS) and the Mid-Day Meal Scheme (MDMS (now subsumed under PM Poshan Scheme) are two major food assistance programs in India. ICDS, launched in 1975, aimed to provide balanced nutrition for young children and pregnant/lactating mothers, but its effectiveness in reducing child malnutrition has been questioned. MDMS, introduced in 1995, addresses classroom hunger for school-going children. However, both programs primarily focused on staple grains and didn't account for local tastes and nutritional needs. Recent reforms are moving towards better nutrition outcomes.

(Pingali, Mittra, & Rahman, 2017)

ICDS initially focused on providing food for children and pregnant/lactating women, assuming lack of food was the main cause of malnutrition. In the late 2000s, there was a call for a more integrated approach to nutrition. MDMS provides meals for school children, aiming to improve enrolment and attendance. However, it faces challenges in terms of infrastructure, staff, food quality, and payment reliability. The Supreme Court's involvement has led to significant improvements in both ICDS and MDMS. (Pingali, Mittra, & Rahman, 2017)

While studies before 2000s found ICDS ineffective, more recent evaluations suggest it has helped reduce malnutrition, particularly among girls. MDMS has been successful in increasing school attendance, but there is limited empirical evidence on its impact on nutritional outcomes. Some studies indicate that participation in MDMS leads to increased nutrient intake in children. Additionally, MDMS acts as a safety net for children facing early-life challenges, resulting in improved nutritional outcomes. (Pingali, Mittra, & Rahman, 2017)

In 2013, India enacted the National Food Security Act (NFSA), providing subsidized foodgrains to a significant portion of the population. It also includes provisions for nutritional support to pregnant and lactating mothers, as well as children up to fourteen years of age. However, NFSA primarily focuses on staple grains and lacks emphasis on micronutrient consumption and diet diversity, potentially falling short in addressing hidden malnutrition. (Pingali, Mittra, & Rahman, 2017)

NFSA aims to integrate various food assistance schemes for improved food and nutritional security throughout individuals' life cycles. Yet, these schemes currently operate independently without much coordination. The act hasn't fully departed from traditional farm interests and populist political influence, which could limit its effectiveness in addressing nutrition security beyond calorie sufficiency. (Pingali, Mittra, & Rahman, 2017)

To enhance nutrition security, there's has been felt a need for policy reforms that promote a balanced and nutritious food system, addressing issues like micronutrient deficiency, child stunting, and the growing challenges of overweight and obesity. While staple grain productivity remains important, there should be a shift towards a more diversified and balanced food system. (Pingali, Mittra, & Rahman, 2017)

Signalling this shift, NITI Aayog published the Multidimensional Poverty Index (MPI) for India in 2021. This National MPI aims to deconstruct the Global MPI and develop a customized version for India, aligned with global standards. The objective is to design comprehensive Reform Action Plans to improve India's position in the Global MPI rankings. Additionally, the United Nations Development Programme (UNDP) and the Oxford Poverty & Human Development Initiative (OPHI) released the Global Multidimensional Poverty Index 2021.

Health constitutes one-third weight in the India national MPI in line with global MPI. Nutrition as an indicator lies within the dimension of health holds half of the dimension's weight and constitutes one-sixth of the total weight in the constitution of the whole India’s MPI. It underscores the role nutrition plays in combating multidimensional poverty and overall wellbeing of a population. In terms of percentage of deprivation among the population, the level of Nutrition has improved from 37.6% in 2015-16 to 31.52% in 2019-20 (National Multidimensional Poverty Index (MPI): A Progress Review 2023, 2023). It implies that level of nutrition has improved by almost 16% in about almost five years, which is a remarkable progress in addressing malnutrition nationally.

Discovering micronutrient deficiencies and development of food fortification

The understanding of nutrition and its significance for human health has been ingrained throughout history. Nutrition can be classified as a public good due to its non-rivalrous nature, meaning one person's consumption doesn't limit its availability to others, and its non-excludable aspect, making it difficult to prevent people from benefiting. Moreover, nutrition's wide-ranging benefits, spanning across age, gender, and socioeconomic status, make it vital for growth, health, and disease prevention. Given its public good characteristics, government intervention becomes justified to ensure equitable access to nutrition.

This section will provide a concise account of contemporary recognition of how micronutrient deficiency emerged along with the solutions that emerged to resolve it focussing on food fortification at a global level. Thereafter, it will delve into the incidence of anaemia as a representative case to acknowledge the diverse factors contributing to it and the corresponding interventions. Overall, this section will highlight the evolving perspective on micronutrient deficiency and eventual inception of food fortification.

Setting Sail

A significant milestone in understanding micronutrient deficiency came with the pioneering work of James Lind in 1753. Lind conducted clinical trials on sailors aboard the HMS Salisbury, leading to his famous report on scurvy. His findings eventually led to the routine issuance of lime juice to British sailors, who became known as "limeys." (Tulchinsky, 2010)

Over the next century, scientific knowledge advanced, highlighting the importance of essential nutrients like iron and iodine for maintaining health. In the 1880s, Kanehiro Takaki demonstrated how dietary changes eradicated beriberi among Japanese sailors. Similarly, Christiaan Eijkman's research in Java linked dietary factors to chicken polyneuritis and neuropathy in humans. (Tulchinsky, 2010)

The term "vitamins" was coined in 1912 by Casimir Funk, leading to significant progress in scientific and public health understanding of these essential nutrients. During the early decades of the 20th century, an epidemic of pellagra in the southern US was investigated by Joseph Goldberger of the U.S. Public Health Service (USPHS), and it was determined to be a nutritional deficit rather than an infectious disease. This led to fortifying flour with B vitamins in many southern states, effectively combating the epidemic. (Tulchinsky, 2010)

In 1917, investigations into goitre among recruits to the U.S. Army led to the conclusion that iodizing salt was the best approach to address the problem. Switzerland and the United States adopted the strategy of fortifying salt with iodine in the 1920s, a measure later recognized by the World Health Organization (WHO) as a globally significant public health initiative. (Tulchinsky, 2010)

Importance of measuring Anaemia

Anaemia, a condition characterized by a deficiency of red blood cells, is a prevalent health issue with significant global implications. The primary cause of anaemia is insufficient iron, a crucial nutrient essential for the formation of haemoglobin, the protein responsible for carrying oxygen in the blood. In addition to iron deficiency, anaemia can also result from deficiencies in other essential nutrients such as vitamin B12, vitamin A, folate, and zinc, all of which play vital roles in red blood cell production and overall health.

The discovery of the link between pernicious anaemia and vitamin B12 deficiency by Gorge Minot and his colleagues in the 1920s marked a groundbreaking advancement in medical science. This important finding not only provided valuable insights into the pathophysiology of anaemia but also laid the foundation for early cytotoxic cancer treatments. Their pioneering work earned them the prestigious Nobel Prize in 1934 and had a profound impact on the understanding and management of anaemia and related conditions. (Mukherjee, 2011)

Around the same time in Bombay, impoverished workers in English-owned cloth mills faced acute malnutrition and lacked access to adequate medical care. Anaemia, particularly prevalent among women who had recently given birth, was evident through blood tests. In 1928, English physician Lucy Wills conducted pioneering research to investigate this enigmatic anaemia in Bombay. She discovered that neither Minot's dietary concoction nor vitamin B12 could cure it. Her groundbreaking discovery came in the form of a remedy found in Marmite, a popular spread in England and Australia, which contained a substance she referred to as the "Wills factor." This mysterious substance was later identified as folic acid, a vitamin-like nutrient present in fruits and vegetables. Folic acid is essential for DNA synthesis and cell division, and its deficiency can lead to a halt in blood cell production, resulting in anaemia, as observed in individuals lacking vegetables in their diet in Bombay. (Mukherjee, 2011)

Lucy Wills' remarkable work shed light on the importance of micronutrients in combating anaemia and highlighted the significance of a balanced diet for overall health. Her findings have had far-reaching implications in the field of nutrition and have underscored the critical role of essential vitamins and minerals in preventing and treating anaemia.

TABLE 6: Causes of anaemia

Nutritional		Non-nutritional	
Iron deficiency	• Iron status ranges from deficiency with anaemia to deficiency without anaemia, normal status with varying stored iron, and iron overload. • Iron deficiency anaemia (IDA) is at the extreme lower end, causing negative impacts on cognitive performance, behaviour, growth in children, and immune status across all age groups. • Iron requirements vary for different groups, with higher needs during childhood growth. • Lack of exclusive breastfeeding and un-supplemented milk diets can cause deficiency in infants. • Blood loss during menstruation and increased requirements during pregnancy and lactation may lead to poor iron stores in women due to traditional eating patterns.	Helminthic infestation	• Helminths like hookworm and flukes cause chronic blood loss and iron loss in the body, leading to anaemia • A hookworm burden of 40-160 worms (depending on the host's iron status) is linked to iron deficiency anaemia (IDA).
		Malaria	• Malaria, particularly by Plasmodium falciparum and vivax, leads to anaemia by rupturing RBCs and suppressing RBC production. • Acute infection can result in decreased RBC production due to marrow hypoplasia. • Plasmodium falciparum is the main cause of severe malaria in endemic regions. • Malarial anaemia poses significant risks of morbidity and mortality, especially in children and pregnant women infected with Plasmodium falciparum. • Malaria during pregnancy increases the risk of maternal anaemia, stillbirth, spontaneous abortion, low birth weight (LBW), and neonatal deaths.
Other micronutrient deficiencies	• Vitamin B12 is vital for RBC synthesis, and its deficiency can lead to megaloblastic anaemia. • Diets low in animal protein, common in India, along with malabsorption due to parasitic infections in the small intestine, may cause Vitamin B12 deficiency and anaemia. • Folic acid is essential for RBC formation, maturation, and cell growth and repair. • Folate deficiency reduces DNA synthesis, leading to impaired cell proliferation and intramedullary death of abnormal cells, resulting in shortened RBC lifespan and anaemia.	Sickle cell disease and thalassemia	• Sickle cell disease is an inherited disorder affecting haemoglobin, leading to recurrent haemolytic anaemia. • Thalassemia is a major haemoglobinopathy worldwide, caused by reduced or absent globin chain in haemoglobin. Approximately 10% of global thalassemia patients are from the Indian subcontinent, with 3.4% being carriers.
		Infections	• Chronic diseases like cancer, HIV/AIDS, rheumatoid arthritis, Crohn's disease, and other chronic inflammatory conditions can disrupt RBC production, leading to chronic anaemia. • Kidney failure is another condition that can cause anaemia.

Source: (The National Guidelines for Control of Iron Deficiency Anaemia, 2013)

The expansion of food fortification as a public health policy

In 1941, President Franklin D. Roosevelt's nutrition conference in the White House recommended fortifying basic foods to prevent silent malnutrition. These recommendations were implemented across the US, Great Britain, and Canada. However, in the post-war period, enforcement of vitamin fortification decreased in Canada and Britain, as clinical rickets appeared to have disappeared. (Tulchinsky, Micronutrient Deficiency Conditions: Global Health Issues, 2010)

During the 1990s, the issue of folic acid and its role in preventing neural tube birth defects gained prominence in public health policy. Although providing supplements to all women capable of becoming pregnant achieved limited compliance, the U.S. Food and Drug

BOX 2

#Future Fortified Global Summit

The September 2015 #Future Fortified Global Summit on Food Fortification in Arusha, Tanzania, addressed achievements and challenges of large-scale food fortification in LMICs. It aimed to build a consensus among global stakeholders for scaling up fortification in alignment with the Sustainable Development Goals. The resulting "Arusha Statement on Food Fortification" outlined commitments to tackle monitoring, compliance, and equity challenges. (Osendarp, et al., 2018)

It highlighted five critical areas for immediate progress:

1. Modest but new investments by governments and donors to ensure technical support and capacity, compliance, and leveraging co-investment by the private sector

2. Improving the oversight and enforcement of food fortification standards and legislation

3. Generating more evidence to demonstrate impact and further guide fortification policy and program design

4. More transparent accountability and global reporting

5. Continuing advocacy for greater attention to fortification by governments

Administration mandated the addition of folic acid to "enriched flour." Canada, Chile, and other countries also adopted mandatory fortification of flour with folic acid as a common approach. (Tulchinsky, Micronutrient Deficiency Conditions: Global Health Issues, 2010)

Proper nutrition is not just about satisfying hunger; it is a fundamental aspect of a human being's everyday life that plays a crucial role in their overall well-being and quality of life. Addressing malnutrition comprehensively and promoting healthy and sustainable diets are essential steps in ensuring the health and prosperity of individuals and communities worldwide.

A case for rice fortification as a complementary remedy to micronutrient malnutrition

In an economy, the food system works in conjunction with various other systems, such as health, water, sanitation, education, and social protection, to ensure that every stage of a human's life is supplied with a safe and nutritious diet. Food fortification, a process of enhancing the nutritional quality of commonly consumed foods by adding vitamins and minerals, requires a vehicle with broad reach and affordability post fortification (UNICEF, 2020).

Rice, alongside wheat and maize, constitutes 94% of total cereal consumption globally (Guideline: fortification of rice with vitamins and minerals as a public health strategy, 2018).

Given its wide consumption, availability, and acceptance, rice stands out as a prime candidate for large-scale fortification efforts. Notably, rice accounts for a significant portion of global caloric intake, providing 30% of total calories in an average diet and exceeding 70% in low-income countries, as per the WHO report on fortification of rice with vitamins and minerals (2018). This widespread consumption presents a valuable opportunity to efficiently deliver essential micronutrients to a large population.

BOX 3

How is rice fortified?

At present, fortified rice is produced using extrusion technology, which involves milling rice into powder and blending it with a premix of essential vitamins and minerals tailored to meet local nutrient needs

The mixture is then extruded to create fortified rice kernels that are combined with regular rice at a ratio of 1:50 to 1:200 (at present, India is going with 1:100), weight basis, resulting in fortified rice with the same aroma, taste, and texture as traditional rice.

Extrusion is the preferred method due to its stability in preserving micronutrients during processing, storage, washing, and cooking, as well as its cost-effectiveness.

The primary objective of rice fortification with vitamins and minerals is to improve the nutritional status of populations, especially in regions where rice is a predominant dietary staple, while simultaneously reducing the prevalence of micronutrient deficiencies such as iron folic acid, vitamin B12, thiamine, niacin, vitamin B6, and vitamin E (Guideline: fortification of rice with vitamins and minerals as a public health strategy, 2018). Given the prevailing circumstances, rice fortification emerges as a favourable approach to tackle nutritional deficiencies and enhance health, particularly among vulnerable population segments. Notably, at the Copenhagen Consensus in 2012, fortification with micronutrients was ranked by a group of Nobel Laureates as one of the most cost-effective investments with significant benefits that could be made.

Establishing effectiveness of rice fortification

The Cochrane Systematic Review "Fortification of rice with vitamins and minerals for addressing micronutrient malnutrition" aimed to investigate in 2019 the effects of rice fortification with vitamins and minerals on nutritional status in the general population aged two years and older, particularly in countries where micronutrient deficiencies are prevalent.

The systematic review included 17 studies involving a total of 10,483 participants from diverse countries, including Bangladesh, Brazil, Burundi, Cambodia, India, Indonesia, Mexico, the Philippines, Thailand, and the USA. Out of these, 12 were randomized controlled trials (RCTs) with 2,238 participants, primarily involving children, and two studies specifically targeted non-pregnant and non-lactating women. In addition to iron, some studies included vitamin A, zinc, or folic acid as fortifying agents, either alone or in combination. To complement the data, five non-randomized studies were analysed, providing valuable insights into the implementation and impact of fortification programs.

The findings of the Cochrane Review suggest that fortifying rice with iron alone or in combination with other micronutrients may have little or no effect on the risk of anaemia. However, the intervention appears to reduce the risk of iron deficiency, which is a positive outcome. Additionally, the analysis indicates that rice fortification may lead to an increase in mean haemoglobin concentrations, which serves as a biomarker for anaemia. This suggests that while rice fortification might not fully prevent anaemia, it can contribute to an improvement in iron status, leading to potential health benefits.

Furthermore, when rice is fortified with vitamin A, the results indicate that it may have little impact on haemoglobin and serum retinol concentrations, another biomarker for vitamin A nutrition. However, it is important to note that the evidence regarding the effect of vitamin A fortification is of low certainty, highlighting the need for further research in this area. Despite the potential benefits of rice fortification, the review also underscores certain limitations and uncertainties. The overall certainty of the evidence was rated as low to very low, indicating the need for caution in interpreting the findings. Additionally, the studies primarily used iron as the fortifying agent, making it difficult to assess the individual effects of isolated nutrients. Further research is required to assess how fortified rice, tailored with specific combinations of micronutrients, influences various health outcomes in diverse populations worldwide. This endeavour aims to acquire a thorough comprehension of its enduring effects, ultimately optimizing health advantages.

The review identified that the studies had varying degrees of risk of bias. While some studies had robust randomization procedures and low attrition rates, others lacked clear descriptions of sequence generation and allocation concealment. To enhance the reliability of future research, it is crucial for studies to adhere to rigorous methodological standards and ensure transparency in reporting.

It is important to look at studies on fortification done on Indian population specifically as well. Syed Zameer Hussain, Baljit Singh and A.H.Rather conducted a study “Efficacy of Micronutrient fortified Extruded Rice in Improving the Iron and Vitamin A status in Indian Schoolchildren” in 2014. The study involved 222 children aged 5-8 years who were attending a subsidized meal feeding program and were depleted in iron and vitamin A. It was a part of the abovementioned Cochran Review as well. The researchers conducted efficacy studies over six months, where they provided the children with micronutrient-fortified rice. The results showed a significant increase in haemoglobin and serum ferritin levels, indicating an improvement in iron status. Additionally, there was a significant decrease in total iron binding capacity, further supporting the positive impact of the fortified rice. The rice fortified with both iron and either vitamin A or beta-carotene had the most pronounced effects on the children’s nutritional status. However, the sensory evaluation revealed that beta-carotene fortified rice did not match the white colour of natural rice. Despite this, the cost analysis indicated that fortification had minimal impact on rice consumption. The researchers concluded that providing micronutrient-fortified rice in school feeding programs can effectively reduce iron deficiency, iron-deficiency anaemia, and vitamin A deficiency in developing countries. Moreover, the extruded micronutrient-fortified rice, except for beta-carotene fortified rice, was well-received due to its excellent sensory characteristics.

A year 2006 study by Diego Moretti, Tung-Ching Lee, Michael B. Zimmermann, Jeannette Nuessli, Richard F. Hurrell titled "Development and Evaluation of Iron-fortified Extruded Rice Grains" aimed to develop iron-fortified rice that tastes and feels like natural rice, using iron compounds that are easily absorbed by the body. They tested different iron compounds like ferrous sulfate, (Sodium iron EDTA) NaFeEDTA, ferric pyrophosphate of various particle sizes, electrolytic iron, and encapsulated iron. The production method involved blending extruded rice grains with different iron levels into natural rice. They evaluated the colour and texture of the extruded grains, measured iron loss during rinsing, and compared the taste of fortified and unfortified rice through triangle tests. The results showed that micronized ferric pyrophosphate had colour scores similar to natural rice, and the cooked extruded grains had comparable texture with less than 3% iron loss during rinsing. Fortification with other compounds led to significant colour changes. However, rice fortified with micronized ferric pyrophosphate closely resembled unfortified rice in both raw and cooked forms in the triangle tests. In conclusion, using micronized ferric pyrophosphate allows the production of iron-fortified extruded rice with excellent sensory characteristics and potentially high bioavailability. According to the Indian standards outlined in The Food Safety and Standards (Fortification of Foods) Regulations, 2018, Ferric pyrophosphate and t is the approved compound or nutrient for fortifying rice with iron, as supported by the aforementioned study.

A 2014 study titled "Micronized ferric pyrophosphate supplied through extruded rice kernels improves body iron stores in children: a double-blind, randomized, placebo-controlled midday meal feeding trial in Indian schoolchildren" investigated if adding micronized ferric pyrophosphate (MFPP) to rice meals can improve iron levels in Indian schoolchildren.

In this study, researchers investigated the effects of fortified rice on the health of schoolchildren. They found that consuming rice fortified with micronized ferric pyrophosphate (MFPP) along with regular rice for 8 months significantly improved the children's iron levels and reduced iron deficiency. Both the fortified rice group and the unfortified rice group showed a significant increase in mean haemoglobin levels and a decrease in anaemia prevalence. However, the additional impact of the fortified rice on haemoglobin status was not distinct from the improvement seen in the unfortified rice group, suggesting other factors may have influenced haemoglobin levels.

The fortified rice group showed better improvement in body iron stores and iron deficiency but did not have a significant effect on reducing iron-deficiency anaemia or improving haemoglobin levels compared to the unfortified rice group. This finding is in line with the three studies aforementioned. One possible reason for this could be that the small-particle-size MFPP used in the fortified rice may not be absorbed as effectively. Moreover, only a small percentage of children in the study had iron-deficiency anaemia, and there may have been concurrent deficiencies in other micronutrients like vitamin C, vitamin A, riboflavin, folic acid, and vitamin B-12, limiting iron absorption.

The study also found that the fortified rice had similar sensory qualities to unfortified rice when cooked. While the bioavailability of iron from the fortified rice was lower than from unfortified rice, providing 21 mg of iron through the fortified rice significantly improved the children's iron stores and reduced iron deficiency. Further large-scale community-based studies are needed to confirm the effectiveness of this fortified rice approach, especially in vulnerable population groups like preschool children, adolescent girls, pregnant women, and lactating mothers. The study highlights the potential of using fortified rice in food security programs to address micronutrient deficiencies in developing countries and improve health outcomes in vulnerable populations.

The study "Multiple Micronutrient-Fortified Rice Affects Physical Performance and Plasma Vitamin B-12 and Homocysteine Concentrations of Indian School Children" in 2014 aimed to assess the effects of fortified rice on the health of children aged 5-8 years attending a subsidized meal feeding program. The researchers conducted efficacy studies over a period of six months and analysed the impact of fortified rice on various health parameters. This study is important as it included nutrients other than iron in its analysis as well.

The results of the study showed significant improvements in vitamin B-12 status and physical endurance among the children who consumed fortified rice. This was indicated by a reduction in homocysteine levels, a surrogate marker for vitamin B-12 status, and enhanced physical performance among the children. The fortified rice also led to a decrease in the prevalence of anaemia in the low-iron group, attributed to increased vitamin B-12 concentration and improved vitamin A status. However, the fortified rice did not have a significant effect on zinc, retinol, or cognitive performance of the children. The study also highlighted the need for further research in areas with more significant micronutrient deficiencies is warranted to fully understand the effects of fortified rice and its potential role in addressing malnutrition in developing countries.

BOX 4

Summary of research studies

The major findings of studies elucidated above can be summarised plainly as follows:

- The findings suggest that rice fortification with iron alone or in combination with other micronutrients may have little or no effect on the risk of anaemia **but can reduce the risk of iron deficiency and increase mean haemoglobin concentrations.**
- Fortifying rice with vitamin A may have little impact on haemoglobin and serum retinol concentrations, but the evidence on the effect of vitamin A fortification is of low certainty, requiring more research.
- Additional studies on Indian populations specifically show **that micronutrient-fortified extruded rice can effectively improve iron and vitamin A status in schoolchildren attending subsidized meal feeding programs.**
- Studies using micronized ferric pyrophosphate in fortified rice have shown promising results in terms of sensory characteristics and potentially high bioavailability of iron.
- Further research is needed to assess the impact of fortified rice on different health outcomes and its long-term effects.
- **Fortified rice shows potential in addressing micronutrient deficiencies in developing countries and improving health outcomes,** but large-scale community-based studies are necessary to confirm its effectiveness, especially in vulnerable population groups.
- **The fortified rice approach can help reduce iron deficiency and improve physical performance and vitamin B-12 status in schoolchildren. However, more research is needed to fully understand the effects of fortified rice on different micronutrients and its role in addressing malnutrition.**

Some recent India specific studies

Local climate plays a significant role in influencing food systems. Moreover, various local factors form the foundation of large-scale feeding programs. These range from the storage conditions in the locality to the genetic predispositions of the end beneficiaries. For instance, Indians may have a higher genetic susceptibility to type-2 diabetes compared to North Americans. Therefore, it is crucial to examine studies conducted on the Indian population to gain a comprehensive understanding of these dynamics.

Gujarat

The study by Mahapatra et al. (2021) aimed to assess the impact of a rice fortification initiative in Gujarat State, India. Specifically, it sought to understand how regular consumption of fortified rice, provided through India's midday meal program, affected the health of school children aged 6 to 12 years. The primary focus was on haemoglobin concentration, which indicates the level of iron in the blood, and consequently, the prevalence of anaemia. Additionally, the study looked at secondary outcomes like cognitive function and tertiary outcomes such as morbidity.

The investigation employed a case-control design and followed school children within the 6 to 12-year age range over an 8-month period as part of a large-scale school feeding program in Gujarat, India. The study had two groups: (1) the intervention group, where children received fortified rice in their school meal (in Ahmedabad and Gandhinagar districts), and (2) the control group, where children received regular rice in their school meal (in Vadodara district). The study selected "case" children from schools in Ahmedabad and Gandhinagar districts where fortified rice was provided, and "control" children from Vadodara district where regular rice was given. The outcome indicators were measures both at the beginning (between February and April 2018) and again 12 months later at the end (between February and March 2019).

The intervention group received fortified rice while the control group received regular rice. Haemoglobin levels and other health indicators were measured at the beginning and end of the study. A total of 1050 children participated, with 973 (484 in the intervention group; 489 in the control group) completing the study. The study design included careful selection of schools and participants to ensure representative and reliable results.

The results revealed significant health benefits associated with the regular consumption of rice fortified with multiple

micronutrients. In the intervention group, there was a noteworthy increase in mean haemoglobin levels (by 0.4 g/dL) with a p-value of 0.001. Moreover, there was a substantial reduction in the prevalence of anaemia by 10% ($p < 0.00001$), indicating a positive impact on overall blood health. Additionally, cognitive test scores showed an 11% improvement ($p < 0.001$) among the intervention group, signifying enhanced mental function.

However, it's worth noting that the study did not observe a significant decrease in morbidity rates or an improvement in school attendance solely due to the consumption of fortified rice. This suggests that other factors might have played a role in overall health outcomes. These may include standard weekly iron and folic acid supplementation, biannual deworming, adherence to optimal handwashing and hygiene practices, and access to quality healthcare.

When compared to a systematic review by Pena-Rosas et al. in 2019, which focused on rice fortified with iron alone or in combination with other micronutrients, this study reported more substantial improvements in haemoglobin levels and a significant decrease in anaemia prevalence. This difference could be attributed to the additional factors considered in conjunction with the fortified rice.

Past studies on fortified rice interventions have demonstrated considerable variability in their impact on haemoglobin levels and anaemia prevalence. This variability may be attributed to various factors, including the specific formulations of micronutrients provided, the presence of enhancing agents, the initial health status of the sample group, dietary diversity, and other health-related behaviours.

Out of the ten studies reviewed, those using fortified rice containing micronized ferric pyrophosphate (mFePP) iron showed mixed results. Only half of these studies reported improvements in anaemia prevalence, indicating the complexity of the intervention's impact. Notably, studies conducted in India that used multiple micronutrient formulations, instead of iron-only, consistently reported positive effects on both haemoglobin levels and anaemia prevalence.

This study from Gujarat contributes valuable insights to the body of literature on fortified rice interventions, particularly in the Indian context. It's important to acknowledge that the prevalence of hemoglobinopathies (conditions affecting haemoglobin synthesis) in the study population may have influenced the results. Compared to Cambodia, where a similar program did not yield significant improvements, the lower prevalence of hemoglobinopathies in Gujarat likely contributed to the positive outcomes observed.

attention, concentration, and intelligence quotient scores, irrespective of the initial iron status. The underlying biological mechanism may be related to iron's role in energy production within the brain's neurons. However, it's important to note that the literature on fortified rice's impact on cognitive function is mixed, likely due to various factors like formulation differences, population characteristics, and diverse methods used to measure cognitive performance.

The study also observed that most of the children in the intervention group (about 71%) had received deworming tablets during the past 9 months. This deworming likely helped improve the absorption of iron from the fortified rice they consumed during the school year.

However, it's noteworthy that the intervention group had a higher rate of diarrhoea in the 2 weeks leading up to the end of the study. This suggests that reducing morbidity (the occurrence of diseases) not only depends on better nutrition but also on adopting healthier behaviours related to water, sanitation, and hygiene (referred to as WASH).

Although both the intervention and control groups maintained a good standard of hygiene and sanitation, the increase

in diarrhoea cases in the intervention group could be linked to their lower consumption of clean drinking water (45% compared to 75% in the control group). This underscores the importance of not only providing nutritious food but also ensuring access to clean water and proper hygiene practices for overall health improvement.

In short, this study discovered that giving school children fortified rice as part of India's midday meal program in Gujarat State significantly improved their haemoglobin levels and cognitive abilities while reducing cases of anaemia. This suggests that including fortified rice in large-scale school feeding initiatives can greatly enhance the health of vulnerable school-aged children.

Additionally, combining rice fortification with other targeted public health measures like WASH (Water, Sanitation, and Hygiene), deworming, and iron-folic acid supplementation could further enhance nutritional outcomes. Raising awareness among communities about the importance of nutritious foods, clean drinking water, and hygiene practices will also play a vital role in improving nutrition.

Maharashtra

The research study employed a quasi-experimental pre-post design, focusing on Kurkheda and Bhamragarh in Gadchiroli as intervention areas, and Etapalli in Gadchiroli as the control block. This initiative aimed to combat anaemia by fortifying rice distributed through the public distribution system, incorporating essential nutrients like Iron, Folic Acid, Vitamin B12, B1, as per the standards of fortification released by the government.

The case group received fortified rice through the PDS, while the control group received traditional rice. Data was collected at baseline and end line. Initially, both areas had similar rates of anaemia (excluding sickle cell anaemia) at around 58%. However, at the end line, the intervention blocks showed a notable decrease to 29.5%, while the control block only saw a slight reduction to 50.3%. This indicates a significant 21% reduction in anaemia prevalence attributable to rice fortification. Qualitative analysis also revealed a positive shift in attitude and acceptance of fortified rice in the program blocks. The dissemination of knowledge through community-level discussions and awareness campaigns played a crucial role in enhancing understanding and acceptance of fortified rice.

The study revealed positive changes in various indicators in both the intervention and control blocks. There was an increase in knowledge and awareness of fortified food through discussions at the community level. Additionally, awareness about health and hygiene also showed improvement. In the intervention blocks, the BMI status of mothers improved. Adolescent girls displayed positive changes in awareness, knowledge, and behaviour regarding fortified food. Women's child-rearing practices and behaviour also improved in these blocks. Most children were registered and regularly visited the Anganwadi centre, enjoying fortified foods. Furthermore, full immunization status showed improvement in both intervention blocks. Positive changes were observed in all indicators related to the consumption and awareness of fortified food.

The Rice Fortification Pilot in Gadchiroli showcased a cost-effective model that can be extended country-wide. The Public Distribution System (PDS) proves effective in reaching every household, significantly boosting micronutrient intake without necessitating behaviour changes from end-users. The fortified rice maintained its taste and required no special preparation, making it a practical solution for addressing anaemia. A successful Public-Private Partnership (PPP) model engaged rice millers in investing in blending machines. By utilizing existing government distribution and supply chain logistics, implementation challenges at scale were minimized. Utilizing rice miller facilities ensured standardized processes, reducing operational challenges and enhancing cost efficiency. Establishing a modified blending system, which costed only a fraction of the proposed one, made it easier for rice millers to participate in rice fortification. This system created in Gadchiroli, utilized local vendors and fabricators. The pilot's progress was assessed and monitored through baseline and end-line evaluations conducted by the IIHMR-Jaipur. Continuous third-party testing of fortified rice was carried out every alternate month. Community mobilization and sensitization workshops were held in the two blocks aimed to address any rumours and misconceptions. The supply of fortified rice in the two blocks was solely supported by Tata Trusts from January to December 2020.

This program anticipated several significant outcomes and impacts. Firstly, it aimed to foster product development through collaboration. This encompassed a broad spectrum, ranging from selecting ingredients and refining processing techniques to establishing legal frameworks. It also involved understanding consumer preferences and demands.

Moreover, the initiative had gained approval for expansion across ten regions in Gadchiroli from both the Department of Food Civil Supplies and NITI Aayog. The project's progress was subject to rigorous monitoring, with results compared against the initial measurements. Additionally, a comprehensive plan to fortify staple foods, particularly rice distributed through the PDS, was trialled in two regions of Gadchiroli.

Given its success, the Government of Maharashtra has decided to implement rice fortification across the entire district. In terms of anticipated impact, the provision of roughly

476,000 quintals

of fortified rice, containing crucial nutrients such as Iron, Vitamin B12, and Folic Acid, through the public distribution system across ten blocks in Gadchiroli over a year was expected to lead to a reduction in the prevalence of Iron deficiency anaemia among 400,000 households.

Achievements of the collaboration between the Government of Maharashtra and development partners supporting rice fortification are notable. The Public Distribution System (PDS), an extension of the government's distribution framework, has helped mitigate logistical challenges, particularly in large-scale implementation. Additionally, utilizing miller premises has led to standardized processes, reducing operational hurdles and enhancing cost-effectiveness. The Gadchiroli pilot serves as a model of an efficient value chain. Here, paddy cultivation, milling, and subsequent distribution through FPS to beneficiaries all occur locally. Furthermore, the proposal for rice millers to bear a significant portion of the CAPEX cost for setting up the blending system demonstrates a commitment to producing high-quality fortified rice. This not only benefits the initiative but also provides a sustainable business model for the millers for future, encouraging further expansion. Overall, this pilot project showcases an effective, scalable, and sustainable model, garnering recognition from NITI Aayog and earning recognition as a Best Case Success Story in Health and Innovation in March 2019.

The advent of Large-scale Staple Food Fortification (LSFF) in India

Osendarp, et al., (2018) define large-scale food fortification as “the production capacity (more than 50 metric tons/d), often a prerequisite for mass fortification, which refers to the reach of a fortified product”.

Food fortification has a rich history, dating back almost a century, and has proven effective in addressing deficiencies in various countries. This process involves adding one or more micronutrients to commonly consumed foods like grains, salt, condiments, sugar, or edible oil at the central level or during production. Typically, government sectors mandate and regulate fortification based on evidence of micronutrient deficiencies or potential benefits to specific populations (Osendarp, et al., 2018). Presently, over 130 countries mandate iodine fortification in salt, while 80 countries fortify cereal grains such as wheat, rice, or maize. Additionally, some countries fortify milk and edible oils

Successes, limitations and insights

India’s initiatives for food fortification primarily targeted supply-side challenges. Historically, the emphasis was on addressing deficiencies in iodine, Vitamin A, and iron, which are commonly lacking in Indian diets. Notably, the fortification of Vanaspati with Vitamin A, dating back to 1953, stands as one of the earliest successful interventions in this regard. In the 1940s, vanaspati lacked vitamin A, unlike ghee, due to the absence of vitamin A in the vegetable oils used for its production. The addition of vitamin A from marine oils was avoided to respect consumer socio-religious beliefs. However, in 1950, synthetic vitamin A from lemon grass oil emerged, prompting the Ghee Adulteration Committee and the Nutrition Advisory Committee (November 1952) to recommend fortification of vanaspati with synthetic vitamin A to enhance its nutritional value and match ghee. In 1951, the Vegetable Oil Products Controller mandated manufacturers to declare vitamin content on the label if claiming vitaminization of vanaspati. (Food Fortification to End Micronutrient Malnutrition: State of the Art, 1997)

Mandatory iodine fortification of salt in India began in 1962, leading to significant public health achievements. (Journey of Food Fortification: Fighting Malnutrition Improving Lives, 2016). As per the recommendations of the Central Council of Health in 1984, the government decided to iodate all edible salt by 1992, with the program initiating in April 1986 in a phased manner. Currently, the country produces 65 lakh metric tons of iodated salt annually.

Household consumption of adequately iodated salt has risen from

51.1% (NFHS III report 2005-06) → **71.1%** (CES report, 2009).

Yet, even post 4th five-year plan (1969–1974), poverty and malnutrition continued to persist in India. The plan relied on economic growth and self-reliance policies, hoping that benefits would trickle down to all levels of society, but this proved insufficient. The 5th year plan then took a direct approach to address poverty, unemployment, and malnutrition, introducing interventionist strategies to increase purchasing power for the poor and expand the social safety net. (Duggal, et al., 2022)

BOX 5

Challenges in overcoming malnutrition

Combating malnutrition is a complex task. Access to nutritious food is increasingly affected by various factors known as demand-side constraints and supply-side constraints.

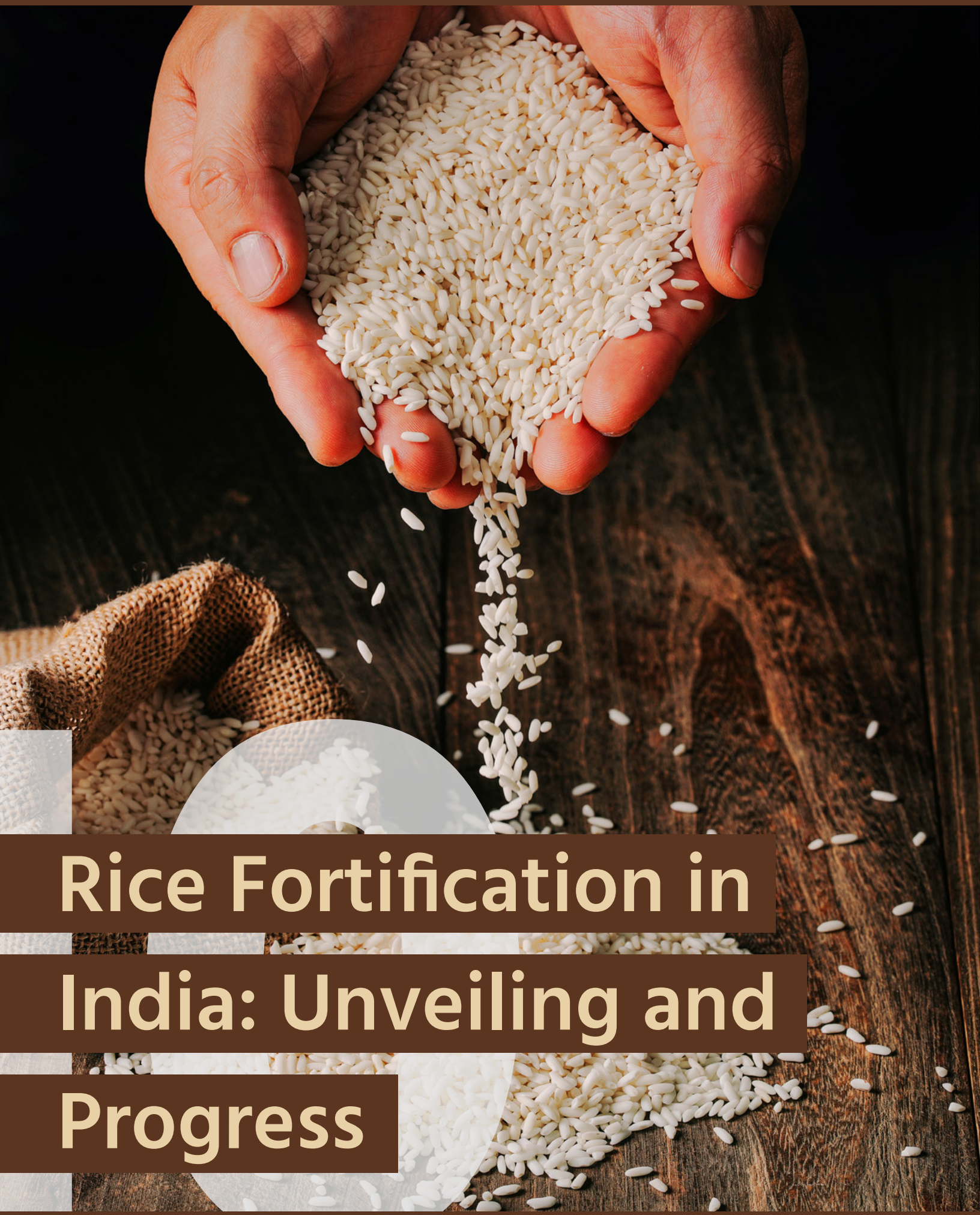
Demand-side constraints:

These include income poverty, limited education, cultural influences, food insecurity, and gender inequality. Poverty makes it hard for people to afford nutritious food, and lack of education leads to a lack of awareness about healthy choices. Cultural norms influence what people eat, and food insecurity makes it difficult to consistently access safe and nutritious food. Gender inequality adds to the challenges, especially for women and girls.

Supply-side constraints:

Supply-side constraints pose challenges in addressing malnutrition, even when there is a demand for nutritious foods. These constraints encompass inadequate food production, inefficient distribution, poor quality, and high prices. Inadequate food production can result from factors like climate change, conflict, or natural disasters, leading to shortages and malnutrition, particularly in high-population growth regions. Inefficient distribution can create imbalances, causing difficulties in accessing nutritious foods even when available. Poor food quality, due to spoilage, contamination, or adulteration, can compromise safety and contribute to malnutrition. Additionally, high food prices can hinder access for those living in poverty, making nutritious foods less affordable.

The National Nutrition Policy of 1993 recognized nutrition as a multi-sectoral issue that required action at various levels. It emphasized fortification of essential foods as a crucial short-term policy instrument for direct intervention. The policy highlighted the need to identify a suitable vehicle for marketing and distributing fortified foods. Salt, being one of the earliest food items to be fortified and widely distributed through markets and government programs, had a highly decentralized marketing process (National Nutrition Policy, 1993). To ensure quality control and broader coverage for the target population, it was deemed necessary to identify a vehicle with greater reach and control over the distributed food items. Additionally, it made a case for intensifying research in iron fortification in rice (and other cereals).



Rice Fortification in India: Unveiling and Progress

In India, rice production has seen steady growth over the years. It serves as the primary sustenance for approximately 65% of the population, providing 50% of their total energy intake (Pathak, et al., 2018). Fortifying rice with vitamins and minerals enhances its nutritional value, compensating for nutrient losses during milling and polishing. Rice plays a crucial role in various government safety net programs, such as the PM Poshan (earlier Midday Meal Scheme), Integrated Child Development Services (ICDS), and the Public Distribution System (PDS).

Thus, rice fortification holds great promise to bridge nutritional gaps, particularly since it serves as the staple food for a large section of the population, including vulnerable and marginalized groups benefitting from government safety net programs. Presently, the state food and civil supplies departments collaborate with rice millers to ensure regular rice supply for distribution through social safety net schemes.

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Key Consultations and Meetings Held on Rice Fortification

BOX 6

Rice fortification elsewhere across the globe

Out of the annual 222 million metric tons of industrially milled rice globally, less than 1% undergoes essential vitamin and mineral fortification. Presently, five countries-Costa Rica, Nicaragua, Panama, India, Papua New Guinea, the Philippines, and the six states in the United States have implemented mandatory rice fortification programs (Global Fortification Data Exchange, n.d.). Additionally, Brazil, Colombia, and the Dominican Republic have large-scale non-mandatory rice fortification initiatives. (Global Fortification Data Exchange, n.d.)

Japan has been fortifying grains added to rice before cooking for several decades, with fortified products available since 1981. Similarly, Costa Rica has mandated rice fortification since 2001, incorporating folic acid, vitamin B1, vitamin B3, vitamin B12, vitamin E, selenium, and zinc. This successful food fortification approach is evident in Costa Rica's reduction of neural tube defects (NTDs), attributed to experiences with fortification, a centralized rice industry, government leadership, and private sector support. (Osendarp, et al., 2018).

Between October 2016 and October 2017, several significant consultations and meetings were conducted to prioritize rice fortification in India. National Summits and Consultations involved high-level officials, such as the Honourable Union Minister of Consumer Affairs, Food and Public Distribution, Shri Ram Vilas Paswan, and Honourable Union Minister of State, Smt. Anupriya Patel, who emphasized the importance of implementing the comprehensive regulations on food fortification. Special meetings with key government ministries, including the Ministry of Health and Family Welfare, Ministry of Women and Child Development, and others, aligned their efforts with fortification goals. (Large Scale Food Fortification in India: The Journey So Far and Road Ahead, 2017)

During this period, 5 zonal consultations were jointly organized by the Ministry of Women and Child Development and FSSAI across different regions, aimed at implementing large-scale food fortification tailored to the specific needs of each zone. State-level meetings were also held to discuss the inclusion of fortified staples in the Public Distribution System (PDS) and various other government safety net programs. Notably, discussions took place with government officials from West Bengal, Delhi, Assam, Karnataka, Punjab, Rajasthan, Haryana, and Madhya Pradesh, among others. (Large Scale Food Fortification in India: The Journey So Far and Road Ahead, 2017)

Technical consultations emphasized strengthening the technical aspects of food fortification, including premix supply and quality. These efforts were carried out in collaboration with some development partner organizations and IIHMR (Indian Institute of Health Management Research). To disseminate India's experience in food fortification internationally, delegations were sent to Sri Lanka and Myanmar to share key learnings in rice fortification. Additionally, Sri Lankan and Myanmar delegations visited India to gain insights into successful implementation strategies. (Large Scale Food Fortification in India: The Journey So Far and Road Ahead, 2017)

Throughout this period, these consultations, meetings, and technical interactions fostered the prioritization of rice fortification in India and served as crucial steps towards addressing nutritional gaps and improving the health of vulnerable populations.

Towards the launch of the pilot scheme

Starting in 2008 and spanning over a decade, FSSAI had noted compelling evidence (including up to 1 million children in pilot studies) showcasing the effectiveness of fortified rice in improving micronutrient status, reducing anaemia, and increasing Hb levels, iron stores, vitamin B12, and zinc levels. It firmly believed that rice fortification held immense potential in India, given its status as the staple food for 65% of the population, especially benefiting vulnerable groups like women and children through safety net programs like ICDS, PDS, and MDM.

The Department of Food & Public Distribution, in collaboration with the Poshan Abhiyaan, aimed to promote nutrition security by exploring the feasibility of fortifying foodgrains distributed through PDS directly to households and targeted welfare schemes (FSSAI, n.d.) . In 2016, rice fortification standards were established and later gazetted in 2018, prompting several states to initiate the scaling up of rice fortification through various safety net programs. The Government of India had integrated staple food fortification, including rice fortification, into the National Nutrition Mission (Poshan Abhiyan) as a complementary approach to combat anaemia and under-nutrition. The "Anaemia Mukt Bharat" initiative under Poshan Abhiyan further emphasized the importance of fortified foods, deworming, food supplementation, and dietary diversification in public health programs. (FSSAI, n.d.)

In 2019, the Department of Food & Public Distribution had launched a pilot scheme to fortify rice in 15 aspirational districts through the Public Distribution System program. The success of these pilots eventually led to a nationwide scale-up in 2022, making rice fortification mandatory in all government rice supply programs[5] . *(More on this in the subsection "Phased unfolding of rice fortification" within this section)*

[5] Although, in the open market rice fortification remains voluntary, there are still few brands of available. FSSAI website lists three brands of fortified rice which are available in the open market. These are Asbah Siver, Daawat Sehat Mogra, and Sri Lohita. For additional information see: https://fortification.fssai.gov.in/commodity?commodity=fortified-rice

BOX 7

Unit cost of fortifying rice

The cost of fortification depends on various factors, such as the rice industry's structure, supply chain complexity, policies, and program scale. A low-cost extruder may range from 35 to 40 lakhs INR, while a high-quality one can cost up to 13.5 crore INR. Additional costs for fortified rice vary from 1% to 10% of the retail price, with an approximate additional cost of INR 0.73 per kg to the consumer, depending on the added nutrients. As production and distribution expand, economies of scale are expected to reduce costs, making rice fortification an effective solution. (FSSAI, n.d.)

Establishing regulations and regulator

In October 2016, the Food Safety and Standards Authority of India (FSSAI) organized a National Summit on Food Fortification, bringing together various stakeholders from government, industry, food businesses, development partners, scientists, and academia. The summit led to the formulation of standards for fortifying key staples like oil, salt, milk, wheat flour, and rice, as well as the launch of a logo for fortified foods, thus firmly establishing fortification on the national agenda (FSSAI, n.d.). Since then, voluntary fortification efforts have commenced for five staples: wheat flour, edible oil, double fortified salt, milk, and rice.

FORTIFIED
SAMPOORNA POSHAN SWASTH JEEVAN

These efforts lead to Food Safety and Standards (Fortification of Foods) Regulations, 2018 which laid down the guidelines for adding essential micronutrients to fortified food products. Manufacturers of such fortified foods are now obligated to provide a quality assurance undertaking, ensuring the adherence to prescribed standards. The packaging and labelling of these fortified foods must clearly indicate the added food fortificant, along with the +F logo and the tagline "Sampoorna Poshan Swasth Jeevan," signifying complete nutrition. (FSSAI, n.d.)

Additionally, the packaging and labelling must comply with the requirements specified in the Food Safety and Standards (Labelling and Display) Regulations, 2020. The regulations also set standards (in terms of the specific nutrients and their range level per kilogram) for fortification of five staple foods: Salt, Oil, Milk, Atta, Maida and Rice.

FSSAI established the 'Food Fortification Resource Centre' (FFRC)[6] as a nodal point, providing technical and implementation support, creating awareness among consumers about nutrition, food safety, and fortification in order to support and align stakeholders (Large Scale Food Fortification in India: The Journey So Far and Road Ahead, 2017). The FFRC was a dedicated platform that encourages and facilitates large-scale food fortification throughout India. It served as a platform, offering guidance on standards, food safety, technology, premix and equipment procurement and manufacturing, quality assurance, and quality control for fortification. It provided all information pertaining to fortification of food, for example, scientific evidence, latest technology, national and international experiences, government circulars and success stories. The centre's approach is to motivate and support the food industry in embracing fortification as a standard practice.

[6] FFRC has now been subsumed within FSSAI as Fortification Division

Phased unfolding of mandatory rice fortification in safety net schemes

The global nutrition crisis and its impact on health, economies, and the environment have prompted action worldwide. 2021 was declared the Nutrition Year of Action, leading to significant commitments at the Tokyo Nutrition for Growth (N4G) Summit.

BOX 8

Leveraging social assistance programs for fortified rice distribution

1. **Public Distribution System (PDS):**
   Households receive ration cards to redeem for rice at fair-price shops, targeting approximately 800 million people.

2. **PM Poshan School meal Program (previously Midday Meal Program):**
   Schoolchildren aged 6-14 years (grades 1 to 8) are served hot midday meals, totalling 118 million beneficiaries (a subset of PDS beneficiaries)

3. **Integrated Child Development Services (ICDS):**
   Pregnant and lactating women, children aged 6-36 months, and children aged 3-6 years receive take-home rations, while older children are provided with hot cooked meals at mother-child health and nutrition centres. This program serves around 110 million people a (subset of PDS beneficiaries)

Implementing fortified rice distribution within these social assistance programs presents a promising strategy to combat micronutrient deficiencies on a large scale in India. (The Proof Is In The Pilot: 9 Insights From India's Rice Fortification Pilot to-Scale Approach, 2022)

In India, a major step was taken by announcing the mandatory fortification of rice in all social safety net schemes by 2024 (Ministry of Consumer Affairs, One Year of Announcement of Rice Fortification, 2022). The programme cost of Rs. 2700 Cr. Per annum will be borne by the central government till its completion in June 2024. The announcement, made on the 75th Independence Day by the Prime Minister, has accelerated efforts to strengthen the ecosystem for rice fortification.

The cumulative annual Fortified Rice Kernel (FRK) manufacturing capacity has increased more than 18 folds from 0.9 LMT (34 FRK Manufacturing) in August 2021to 17 LMT in 2022 (More than 400 FRK manufacturers), and measures for standardization and quality control are being implemented to ensure the effectiveness of the intervention (Kumar & Shekhar, 2021). This initiative was preceded by completion of Centrally Sponsored Pilot Scheme on "Fortification of Rice & its Distribution under Public Distribution System" This pilot scheme had a duration of three years, starting from 2019-20, with a total budget of Rs. 174.64 Crore. The focus of the scheme was on 15 districts across 15 states, with a preference for one district per state. (Ministry of Consumer Affairs, One Year of Announcement of Rice Fortification, 2022)

The Government of India has undertaken a comprehensive initiative to supply Fortified Rice in every Social Safety Net Scheme across the country by 2024. This ambitious endeavour is being executed in a phased manner, and significant progress has been achieved in the last two years. Let's delve into the key phases and developments:

1. PHASE- I:

During the fiscal year 2021-2022, the initiative commenced by covering Integrated Child Development Services (ICDS) and the Prime Minister's POSHAN Abhiyan (PM POSHAN). In this initial phase, nearly 17.51 LMT (Lakh Metric Tons) of Fortified Rice was successfully distributed in various States and Union Territories.

2. PHASE- II:

Building upon the success of Phase-I, the program expanded its scope to include the Targeted Public Distribution System (TPDS) in 27 States and Union Territories. Approximately 105 LMT of Fortified Rice was lifted for distribution through TPDS during this phase. Additionally, about 29 LMT of Fortified Rice was procured and distributed for ICDS and PM POSHAN, bringing the total Fortified Rice lifted to approximately 134 LMT during the financial year 2022-2023.

3. PHASE- III:

The Department of Food and Public Distribution (DoFPD) is now fully committed to completing the coverage of all remaining districts, except those primarily consuming wheat, before the targeted date of March 2024. This final phase aims to ensure the availability of Fortified Rice in all relevant social safety net schemes across the entire nation, further enhancing the nutritional security of the population. Union Minister of State for Food and Public Distribution Ashwini Kumar Choubey has said "From food security we are moving towards nutrition security. Hon'ble prime minister had announced to complete this by 2024. But recently we and other senior reviewed the plan of action about fortified rice. We have planned to achieve the target before 2024,"

TABLE 5: Overview of phased implementation of rice fortification in India

Particulars	Details	PHASES			
		Pilot Scheme	Phase 1	Phase 2	Phase 3
Duration/ time of completion		2019-20	Till March 2022	The target date of completion was set as March 2023 but targets were achieved by 27 September, 2022, well ahead of time.	Commenced on 1 April, 2023 with the aim to achieve the targets by September 2023.
Coverage		15 Aspirational districts (later revised to 11)	Covering ICDS and PM POSHAN	Phase I + TPDS and OWS in all Aspirational and High Burden Districts on stunting (total 291 districts	Phase II+ covering the remaining districts of the country (except wheat consuming districts)
Proposed/ Incurred Cost		174.64 Cr	266.91 Cr	1323.38 Cr	2679.47 Cr
Cost Borne by			Ministry of Women and Child Development & Department of School Education and Literacy respectively for the financial year 2021-22	Cost covered as a part of food subsidy bill of Department of Food & Public Distribution	Cost covered as a part of food subsidy bill of Department of Food & Public Distribution
Achievements		17.51 LMT of fortified rice have been lifted by States/UTs for distribution under ICDS and PM POSHAN	Phase-I covered ICDS and PM POSHAN. It was implemented during 2021-22 and nearly 17.51 LMT had been distributed in the States/UTs.	• Phase II of the Rice Fortification was completed well ahead of target of 31st March, 2023 by covering all the total of 269 districts in 27 states targeted rice consuming districts. • 105 LMT of Fortified Rice was lifted by Phase II targeted 27 States/UTs for PDS distribution. • 29 LMT was lifted by the States/UTs under ICDS and PM POSHAN in Phase II. • Thus, a total of about 134 LMT fortified rice lifted in the FY 2022-23.	
Capacity	No. of Mills		2690 mills (by August 2021)	18227 mills (by March 2023)	
	Blending Capacity		3.67 LMT (in August 2021)	156 LMT (in March 2023)	
	No. of FRK Manufacturers		34 (by August 2021)	400 (by April 2023)	
	Annual Fortified Rice Kernel (FRK) manufacturing capacity		0.9 LMT	17 LMT	
NABL accredited Labs for testing of fortificants			20 (by August 2021)	48 (by April 2023)	

Source: (Ministry of Consumer Affairs, One Year of Announcement of Rice Fortification, 2022); (Ministry of Consumer Affairs, 269 districts in 27 states distributing Fortified Rice under Targeted Public Distribution System, 2023); (Ministry of Consumer Affairs, 92.77 LMT of fortified rice lifted in Phase II under TPDS for Aspirational and High Burden Districts, 2023); (Administrative approval for Supply of Fortified Rice, 2022)

The successful implementation of these phases reflects the government's dedication to improving the nutritional quality of essential food supplies and uplifting the health and well-being of its citizens. The Fortified Rice initiative is poised to have a far-reaching impact on public health and nutrition, contributing significantly to the nation's overall well-being and development. Dr Prashanth Thankachan, an expert in micronutrients at St John's Research Institute, says that “In a country with a lack of diversity in food consumption, supplying iron-fortified rice is a low-cost, safe and effective means of addressing malnutrition,”

Additionally, the number of rice mills having blending infrastructure has increased from 2690 to 18227 from August 2021 to March 2023, significantly increasing monthly production capacity. This fortification program plays a crucial role in addressing nutritional deficiencies and has gained support from various stakeholders. Educational campaigns are underway to raise awareness about the nutritional benefits of fortified rice, contributing to nutritional security and combating malnutrition and anaemia in the country.

Currently, the Food Safety and Standards Authority of India (FSSAI) is working on standardizing FRK and facilitating the establishment of more NABL accredited labs and Bureau of Indian Standards Standardization of Extruders/Blenders to ensure quality.

DIAGRAM 1:

Unfolding of Rice fortification in India: a brief timeline

1950s

Salt iodization begins in independent India

1960s

Edible oil fortification with vitamins A and D begins

1962s

National Goitre Control Programme initiated to ensure availability and production of iodized salt

1962s

The Nutritional Prophylaxis Programme agianst Nutritional Blindness established, implementing initiatives like fortifying milk with Vitamin A to prevent nutritional blindness

1970s

The Nutritional Anaemia Prophylaxis Programme established, implementing initiatives like fortifying salt with iron to combat anemia.

2000s

Fortification of rice and wheat with iron, folic acid, and vitamin B12 begins. Mutiple pilot studies are launched across the nation

2016s

Food Safety and Standards (Fortification of Foods) Regulations, 2016 are notified.

2018s

Fortification of edible oil with vitamin A and D becomes compulsory across the country. Regulations on fortification are operationlised

2019-20

Centrally Sponsored Pilot Scheme on Fortification of Rice & its distribution through Public Distribution System is launched.

2022

Supply of fortified rice is made compulsary across social assistance programs.

Pilot-to-scale approach: Understanding India's Rice Fortification journey

An Ex-FSSAI CEO has remarked

"Rice is one important staple that has capacity to change the nutrition profile of the nation, owing to its consumption. Rice is consumed by more than half of India's population. Reaching even half of those people would mean providing better nutrition to 470 million people. Rice also has the highest uptake in government safety net programs- 3.2 crore MT. Fortified rice is an efficient way to reach out to the rich and the poor".

Introducing fortified rice into social assistance programs, thus, was a huge opportunity to improve nutrition in India. Many people in India lack important nutrients, and these programs reach millions. However, there were challenges due to the country's unique situation, large population, decentralized governance, and fragmented rice industry. The concerned activist community also adds complexity.

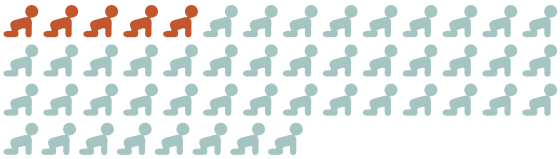
In response to this, the national and state governments of India worked with a host of organisation in a special approach called 'pilot-to-scale.' They conducted four large-scale tests in different programs to demonstrate the feasibility of including fortified rice. Alongside this, government and organisations worked in tandem towards setting standards, local production, integration into government distribution systems, and education efforts in various contexts. This built the momentum for fortified rice across the country.

Despite India's advancements in economic and sustainable development, a substantial portion of the population still grapples with inadequate dietary intake.

The National Family Health Survey

conducted between 2019 and 2021 underscored this concern, revealing that merely

11% OF CHILDREN AGED 6-23 MONTHS



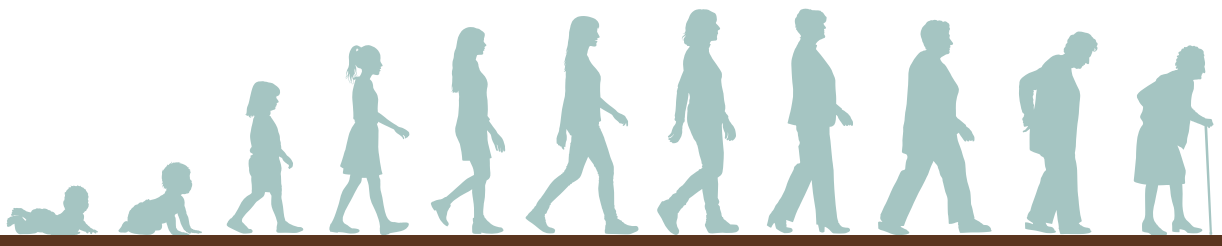
received a diet meeting the minimum acceptability criteria in terms of food group diversity and meal frequency.

Similarly, adult dietary practices exhibit shortcomings; approximately

49%

of women only sporadically incorporate fruits into their meals.

Moreover, a notable majority refrain from regular consumption of poultry, meat, fish, or eggs, with nearly one-third (30%) of women adhering to a vegetarian regimen and thereby abstaining from these vital animal-derived nutritional sources.



In instances where diets do not encompass animal-sourced foods, a requisite condition for meeting all nutritional needs is a notably diverse dietary regimen. This necessity is particularly pronounced among demographics identified as nutritionally vulnerable, as they exhibit elevated demands for essential micronutrients relative to energy intake. Insufficient intake of nourishing foods can give rise to deficiencies in critical micronutrients, thereby imperilling overall health, impeding childhood development, and reducing adult productivity.

Disturbingly, anaemia, attributable to dietary iron deficiency,

afflicts a substantial

67%

of Indian children aged 6-59 months

as well as over half

57%

of women of reproductive age.

The integration of fortified rice into existing social assistance programs presented a strategic opportunity, given the programs' established reach to some of the most economically disadvantaged and nutritionally vulnerable segments of society. Within this context, three extant rice distribution initiatives were identified as avenues for enhancing participant nutrition by substituting conventional rice with a fortified variant enriched with essential nutrients such as iron, zinc, folic acid, vitamin A, thiamine, riboflavin, niacin, vitamin B6, and vitamin B12. Leveraging the infrastructure of these existing programs, including their targeting and distribution mechanisms, obviated the need for incurring additional program establishment costs, with the associated increase in expenditure being relatively minor. (Gie, 2022)

The piloted initiatives served as evidentiary groundwork for a broader implementation. India's rice industry is characterized by its fragmented nature, while the scale of the social assistance programs, particularly the Public Distribution System (PDS) catering to a demographic of 800 million, prompted concerns regarding the feasibility of deploying rice fortification on the requisite scale and maintaining commensurate quality standards. Some stakeholders expressed reservations, contending that the successes witnessed in other countries might not be readily replicable in the Indian context. To address these apprehensions development partners collaborated with both national and state-level governments in a distinct "pilot-to-scale" strategy, conducting four extensive pilot projects in disparate regions of the country. Three were implemented within the purview of the school meal program, while the fourth was integrated into the Integrated Child Development Services (ICDS) program. These endeavours were orchestrated with the aims of assessing implementation efficacy, demonstrating operational effectiveness, and iteratively refining the programs. The pilot initiatives effectively demonstrated the feasibility of incorporating fortified rice into the prevailing social assistance distribution networks and supply chains, underscored the potential for cost reduction through economies of scale, and substantiated a marked reduction in the prevalence of anaemia amongst school-aged children. Insights garnered from operational research during the pilot phase were instrumental in refining program parameters, with rectifications being instituted in the subsequent phase based on lessons learned from the inaugural pilot. (Gie, 2022)

Having borne witness to the success and viability of the pilot initiatives, the national government made a pivotal commitment in 2021 to a comprehensive scaling-up endeavour, pledging that all rice disbursed through the triad of food-based social assistance programs would be fortified by 2024. Notably, within the Indian context, it was imperative that the pilot projects be of sufficient scale to furnish substantive empirical evidence, with the inclusion of up to one million children, thereby validating effectiveness on a grand scale. Another salient factor contributing to the success of this approach was the discerning strategic measure to conduct a pilot initiative (conducted by World food programme) within the constituency of the Prime Minister Modi (Varanasi), an undertaking that garnered heightened governmental attention toward the merits of fortified rice. The Indian "pilot-to-scale" framework may serve as a valuable blueprint for nations wherein government endorsement for fortification is not yet fully realized. Conversely, in contexts where government advocacy has been established, the sharing of cross-national experiences and advocacy efforts may suffice, potentially expediting the process of achieving widespread implementation. An alternative approach might entail countries initiating a pilot project to gauge feasibility and acceptability, with the assessment of anaemia impact potentially necessitating a protracted timeline. (Gie, 2022)

Assuring a reliable demand and substantial market for fortified rice was instrumental in incentivizing private sector investment. This guarantee played a pivotal role in attracting investments. The incorporation of fortified rice within social assistance programs established a dependable market, with further reinforcement from the national government's public commitment to its utilization in these initiatives. This assurance led to a noteworthy response from the private sector, evident in the substantial increase of fortified kernel suppliers from 18 to 154 nationwide within a single year, as of early 2022.

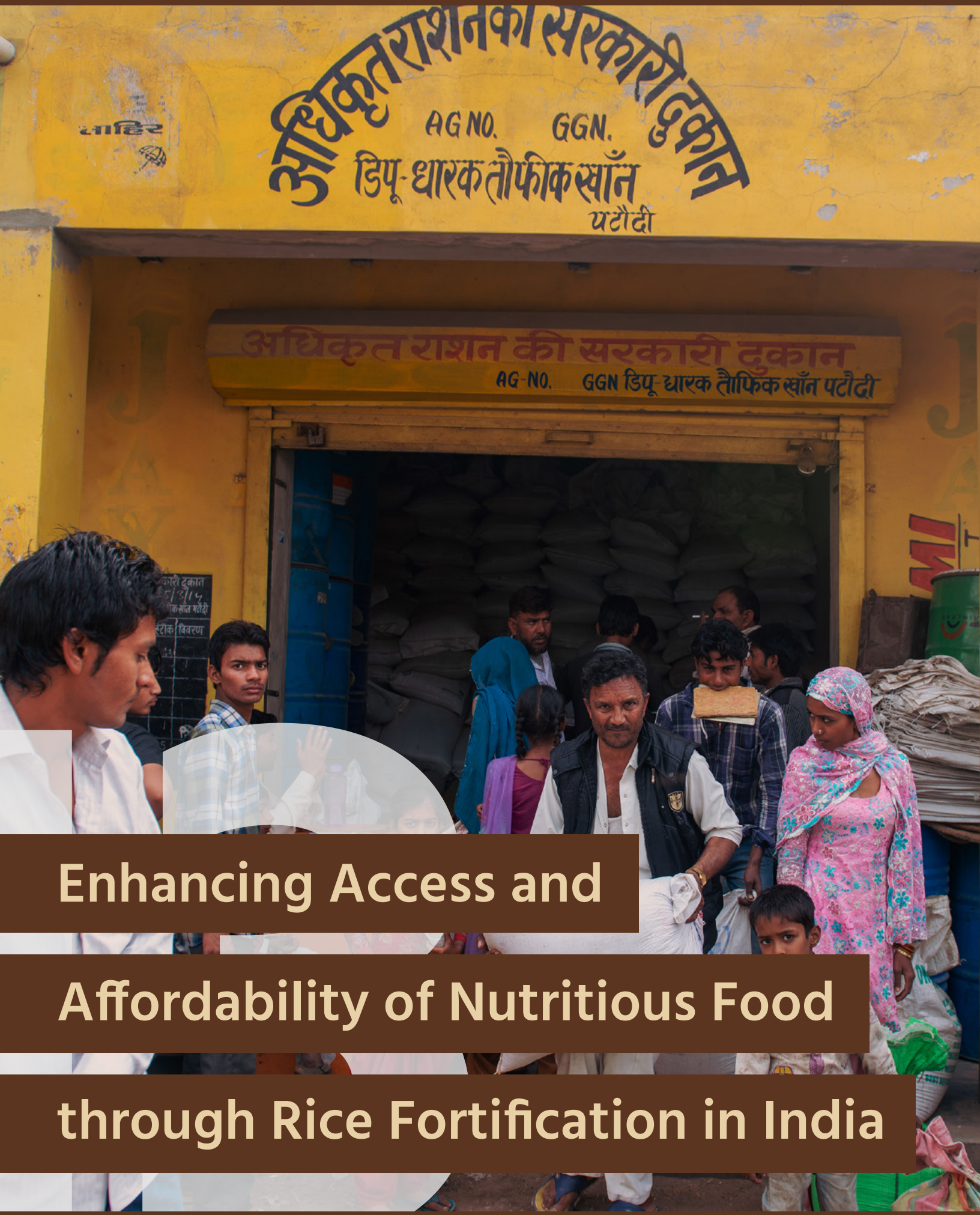
Comprehensive engagement across the entire value chain proved essential in the successful expansion of the endeavour. The importance of addressing all facets of rice fortification, spanning from production to distribution systems and culminating in consumption was promptly recognized. It required bolstering the private sector's capacity for fortified rice production. (Gie, 2022)

This entailed the provision of training and sensitization for local millers in the production of fortified kernels, as well as extending support to facilitate the blending of fortified kernels with non-fortified rice. Concurrently, it required assistance in the development of robust supply chain and distribution systems, the establishment of costing and monitoring frameworks, the implementation of rigorous food safety and quality protocols, the setting of national standards, and the undertaking of educational and communicative initiatives within communities to advocate for fortified rice. (Gie, 2022) Direct involvement and engagement with communities played a pivotal role in garnering support for fortified rice. While several organisations collaborated with the government in crafting communication materials at the national level, they also implemented effective strategies for social and behavioural change at the grassroots level. A particular focus was placed on targeting school cooks through Social and Behaviour Change Communication (SBCC) campaigns, urging them to adopt cooking methods that preserve a higher nutrient content. Additionally, the conduct of cooking and tasting demonstrations proved to be a highly effective strategy. Some organisations, which were involved with the government effort, partnered with local organizations to visit communities and prepare a local dish utilizing fortified rice, thereby showcasing its ability to maintain the same taste and aroma as unfortified rice. (Gie, 2022)

Collaborative endeavours involving multiple organizations have substantially strengthened the promotion of fortification. “Poshtik” serves as an example of a multi-agency advisory network focused on fortification. This network comprises a diverse array of development partner organizations. “Poshtik” offers global experience in technical know-how and implementation experience, with a specific emphasis on its implications for nutrition and public health. This collaborative effort aimed to enhance and amplify advocacy for fortification. (Gie, 2022)

‘Poshtik’ also proved invaluable in addressing concerns raised by organizations and activists apprehensive about fortification. It presented a united front of reputable organizations, effectively communicating the evidence-based merits, scientific underpinnings, and safety of fortification. The robust scientific foundation supporting these responses played a critical role in allaying apprehensions. Furthermore, the potential of organizations to enhance this by disseminating operational research findings and evaluations through peer-reviewed scientific literature was also explored. (Gie, 2022) India made substantial progress in rice fortification by engaging in study visits and exchanges with other nations. Indian delegations undertook visits to Costa Rica, renowned for its successful fortified rice program. Additionally, India played host to delegations from South Asian countries, including Sri Lanka, Bhutan, and Bangladesh, who sought to glean insights from India's experiences. Through open sharing of knowledge and solutions pertaining to various facets of fortification—such as multisectoral collaboration, cost analysis, standard setting, blending methodologies, and addressing challenges—India contributed to the advancement of fortification efforts in these countries, sparing them the need to start from scratch. (Gie, 2022)

While the benefits of these exchanges for the countries seeking to learn from India are evident, there was an additional positive consequence. These interactions bolstered the confidence and pride of the Indian government in their own fortification endeavours, reaffirming their unwavering commitment to enhancing rice fortification within the nation.



Enhancing Access and Affordability of Nutritious Food through Rice Fortification in India

For three years now, the concerted effort to combat nutrient deficiencies and malnutrition through the fortification of rice in all social safety net programs by the year 2024 has been underway. This endeavour was launched in recognition of the fact that, while there has been a decline in hunger levels in India, progress has been gradual. When we scrutinize the situation in terms of absolute numbers, it remains a cause for concern.

According to a comprehensive report by the Tata-Cornell Institute released in 2020, it was revealed that approximately 194 million people in the country were still grappling with undernourishment during the period of 2016-18. This represents only a modest 8% decrease from the 210 million undernourished individuals documented in 1990-92.

Given these statistics, the introduction of fortified rice is considered a pivotal step in the battle against hidden hunger. Rice, being a staple sustenance for 65% of India's populace and a staple within government safety net programs, holds immense potential for enhancing nutrition by incorporating essential vitamins and minerals. The principal objective is to enrich rice with essential nutrients, particularly in regions where rice serves as a dietary cornerstone, thus concurrently mitigating micronutrient deficits. As it stands, fortified rice is now slated for distribution in every district of each state, with the notable exception of regions that are predominantly reliant on wheat consumption. This targeted approach ensures that regions with varying dietary patterns receive the most appropriate nutritional support.

Ensuring access to proper nutrition is a crucial component of public health and a fundamental role of the welfare state. Access can have several constituents or dimensions. Penchansky and Thomas (1981) describe access in connection to health care systems. They argue that the components of access in a policy are a dynamic concept. Access has to be seen in the context of communication between the system and an individual. An individual's circumstances define her ability and willingness towards utilization of a service.

The concept of nutrition access encapsulates various dimensions, including Accessibility, Availability, Acceptability, Affordability, and Adequacy. Each of these above stated components of access are not independent of each other (Penchasky & Thomas, 1981). All of them work together to bring out a service's effectiveness in terms of access. Together, these aspects shape the convenience and effectiveness individuals experience when accessing and utilizing these vital services.

Accessibility pertains to how easily a service can be reached, taking into account both its location and the time it takes to get there. An accessible service is that which can be provided to the consumer within a reasonable distance. It also includes time required in supply of service as one of the factors affecting access. In India, the focus on social assistance is geared towards supporting vulnerable populations.

This is achieved by incorporating food fortification into three existing programs, namely the

Public Distribution System (PDS)

800Mn individuals

PM Poshan School meal Program catering to

118Mn Students

the Integrated Child Development Services (ICDS) covering

110Mn Recipients

(ICDS and PM POSHAN fall under PDS for grain distribution).

By integrating fortified rice into these initiatives, India addresses micronutrient deficiencies on a large scale, ultimately improving accessibility.

Further, the provision of service should be such that the supply of service and its demand are somewhere around equilibrium. The resources required in supply of the service should be adequate and volume of demand should be sustainable over a period of time. The proximity of ration shops, provision of school meals, and availability of nutrition centers further contribute to facilitating access. These well-coordinated efforts at the grassroots level showcase India's administrative prowess and its efficient use of resources in order to ensure the provision of services is substantial and sustainable.

Adequacy focuses on fine-tuning the framework to ensure efficient service provision. An adequate service is one in which the organisational structure is optimised to function well (Penchasky & Thomas, 1981). The organisation of service or the institutions associated with it work in tandem to provide smooth delivery of service. Associated bodies such as the Department of Food and Public Distribution, state food and civil supplies departments, and local rice millers work together to ensure a seamless service. This collaboration is supported by the FSSAI, which establishes food quality standards, and the FFRC (now Fortification Division within FSSAI), compliances and raises awareness. Through this synchronized endeavour, comprehensive service adequacy is guaranteed

The access to a service depends on consumer's perception. The acceptability of fortified rice is apparent from the procurement of 134 LMT in 2022-23, and the successful completion of the second phase in 269 districts ahead of schedule. This demonstrates that society is embracing the initiative, which is further supported by a pilot program in 15 Aspirational districts and additional research conducted by FSSAI. The gradual introduction, in accordance with public preferences, underscores the widespread acceptance and perceived value of fortified rice.

Access also depends on the cost associated with the service. The cost of supply of service needs to be as low as possible keeping in mind the quality. Further, the cost incident on consumer should also be as low as possible (Penchasky & Thomas, 1981). This cost will not only include the cost of service but other costs as well for example the cost of travelling and accessing the information regarding the service. Ensuring affordability in rice fortification thus encompasses expenses related to both service delivery and consumer-related costs such as travel. The intricacies of the industry, supply chain, policies, and program size influence the range of fortification expenses. These vary from approximately INR 35-40 lakh for cost-effective extruders to INR 13.5 crore for higher-quality models. Additional expenses for fortified rice, constituting 1-10% of the retail price, come to about INR 0.73 per kilogram, depending on the incorporated nutrients. With the expansion of production, economies of scale are anticipated to bring down costs, rendering rice fortification a viable and practical solution.

Cost is also dependent on equilibrium between demand and supply of a service. In this regard the mandatory supply of fortified rice in the social safety programmes has instituted a sense of assurance among the rice millers and FRK suppliers. When standards or guidelines for food fortification are voluntary in nature, for example through industry-wide coalitions, the challenge of driving scale and systemic impact is obviously even greater. In the absence of strong consumer demand, millers lack the market incentives to invest in new equipment, processes or products and have no motivation to incur additional costs or risks that won't enhance their competitiveness or that they cannot share with or pass onto consumers. (Tewes-Grad, Gilbert, & Nelson, 2023

However, the widespread effectiveness of government interventions is hampered by insufficient information dissemination and limited behavioural change. Take, for instance, the 'Anaemia Mukt Bharat' program, which has been in operation since 2018-19. Its goal is to provide iron and folic acid (IFA) supplements to pregnant women for a minimum of 180 days, starting from the fourth month of pregnancy, regardless of their anaemia status. Surprisingly, NFHS 5 data reveals that in 19 major states, less than half of pregnant women completed the full course, despite the availability of tablets. This highlights the critical need for increased awareness to ensure accessibility.

Raising awareness involves effectively communicating the goals, objectives, and vision of service policies to both consumers and stakeholders. This is particularly crucial for marginalized communities, which may have limited access to official communication channels. Additionally, within the organizational framework, it is vital to ensure that the supply side is well-informed about the availability of the service and its potential beneficiaries. (Saurman, 2016)

Saurman (2016) weighs the constituents of access given by Penchansky and Thomas (1977) and adds one of her own. As per Saurman, Awareness is also an integral element. Awareness is effective communication of the aims, objectives and vision of a service policy to the consumers and other stakeholders. According to Saurman (2016), Awareness has become a presumed dimension to access. It is the need of the hour to acknowledge that awareness helps in finding the right fit between the user and the service. (Saurman, 2016)

Ongoing efforts are being dedicated to promoting public knowledge about the nutritional advantages of fortified rice through informative campaigns, involving the Food Safety and Standards Authority of India (FSSAI), experts, and Development Partners. The number of FSSAI-notified, NABL-accredited laboratories for fortification testing has increased from 20 to 48 as of August 2021. This expansion aims to instil public confidence in the safety of fortified rice.

Additionally, the Food & Public Distribution Department of the Ministry of Consumer Affairs has also devised a Standard Operating Procedure (SoP) to ensure adherence to Quality Assurance (QA) and Quality Control (QC) protocols during the production and distribution of fortified rice or Fortified Rice Kernels (FRKs). FSSAI, acting as the regulatory and licensing authority for food fortification, has formulated standards for FRK, Pre-mix, and has issued directions to all stakeholders for the immediate operationalization of these draft standards.

Status of fortification of other food commodities: Wheat and Salt

Wheat

According to the FSSAI, wheat is the primary food for the majority of people in regions where wheat is extensively cultivated (specifically in North, West, and Central India). It is typically consumed in the form of homemade chapattis or rotis, which are unleavened flatbreads made using custom-milled atta, meaning whole wheat flour.

The projected wheat consumption for the year 2018-19 stands at

93Mn metric tons

This highlights that wheat flour presents itself as a viable option for fortification, a method aimed at enhancing the overall nutritional well-being of the general populace. (FSSAI, n.d.)

However, there are several challenges linked with fortifying wheat flour. These challenges will be thoroughly examined in the two studies discussed below.

Banerjee et al. (2011) reports on a randomized evaluation of an experimental community-level iron fortification program in Udaipur district, Rajasthan. The program was designed to provide the option for iron supplementation for households who do not buy processed food (including flour), and can therefore not be targeted by centralized fortification. Local millers were trained and supplied with simple equipment to fortify flour in a safe and easily implemented way.

Flour was fortified between
30 AND 40 PART PER MILLION, WHICH WAS ESTIMATED TO BRING BETWEEN

25% & 50% of the recommended daily intake of iron for people who consumed about 300g of fortified flour per day.

Program take up increased steeply over the first 6 months, but subsequently declined. Ultimately take up was quite low (around 30% of flour was fortified). The program was effective in reducing anaemia as long as the take up was high enough, but ineffective when and where take up was low. (Banerjee, Duflo, & Glennerster , 2011)

It also reduced symptoms of fatigue when take up was sufficiently high. It did not lead to other improvement in health, or to increases in labour supply. Perhaps as a consequence, willingness to pay for the program appears to be low: the drop of take up was faster among people whose nearest miller was not fortifying flour as well as for those who had to walk more than 1.5 kilometres to find a fortifying miller, presumably because people switched back to their normal miller after a while. (Banerjee, Duflo, & Glennerster , 2011)

A 2016 report by Food Fortification Initiative explored the supply chain of wheat in Haryana to understand the typography needed to be dealt with for fortification initiatives. It identified that wheat flour is considered as purchased on the open market when manufacturers and consumers acquire it through regular retail channels like flour millers, local shops, and markets. This category encompasses various types of wheat flour, including branded and semi-branded atta, loose bulk atta, and wheat flour (often referred to as maida) used in products like biscuits, snacks, and bread.

In Haryana, the majority, 94%, of wheat flour is used as atta, rather than in products made with maida like biscuits and bread. Open market atta flour is primarily limited to branded and semi-branded varieties, with only 14% (0.41 MMT) of the market share. The remaining 79% of atta comes from wheat milled by service chakkis.

This means that the opportunity to fortify open market wheat flour is restricted to 0.14 MMT of maida and 0.41 MT of branded and semi-branded atta. However, fortifying only these two types of flour may have limited impact on public health, given the low availability of maida and the fact that only a small number of urban, higher-income households rely on branded or semi-branded atta.

In Haryana, there are different groups of consumers with varying access to fortified wheat flour. Firstly, about half of the population does not participate in the open market system. These individuals either keep the wheat they grow or receive it as payment from landowners, relying on their own chakki mills at home. They are unlikely to benefit from fortification efforts.

Secondly, it is crucial that fortified atta matches the qualities of chakki atta, as any deviation could lead consumers to reject the flour. Additionally, approximately half of the state's population are beneficiaries of the Public Distribution System (PDS), receiving wheat grain from the government at reduced prices. If the state were to provide wheat flour instead of wheat grain to these beneficiaries, it could be an effective way to distribute fortified wheat flour. It's important to note that focusing solely on fortifying flour available in the open market would leave out lower-income households, missing an opportunity for them to benefit from fortification.

Finally, 15% of the wheat in the state is acquired in the open market as wheat grain and then processed in independent chakki mills for a fee. Similar to fortification at home-based chakki mills, ensuring fortification in these individual mills presents logistical challenges, making this wheat flour unsuitable for fortification efforts.

In Haryana, there are four options for fortifying wheat flour, each with different infrastructure requirements and operating costs:

1. Upgrading single chakki mills with basic grading and pneumatic systems for PDS distribution. These mills can produce a maximum of 2 MT/day.
2. Upgrading commercial chakki mills with multiple units, meeting hygiene standards, and potentially accessing a regional laboratory. These mills can produce up to 20 MT/day of atta.
3. Creating hybrid mills with roller-chakki lines capable of producing simulated atta. This modification requires significant investments and could produce an estimated 60 MT/day.
4. Establishing modern atta mills with automated systems and internal laboratories. These mills can produce up to 130 MT/day per line, with the option to combine four lines for a total production of 520 MT/day.

Operating costs per kg vary among these options, with modern atta mills becoming more cost-effective as utilization rates increase. The decline in utilities, manpower, and investment costs is significant for modern atta mills compared to small chakki mills at the highest utilization rates.

The high operational costs of traditional chakki mills are attributed to greater manpower requirements for supervision and monitoring. Considering the annual volume of the PDS program, using a modern atta mill for conversion proves to be more cost-effective in the long run, with a 33% reduction in operating costs compared to roller flour mills.

Converting wheat to atta for distribution will require bids from mills with the capacity to produce atta – not just reconstituted whole-wheat flour. If the distributed atta does not have the same characteristics of chakki-milled atta then beneficiaries may reject the flour. If the Government of Haryana decides to convert wheat to atta for welfare scheme distribution, options for sourcing fortified atta are the same as above for the open market system – commercial chakki mills and roller flourmills with dedicated chakki lines. However, in that case, the current milling infrastructure will require extensive investments to modernize milling all PDS wheat is converted to atta.

In general, fortifying wheat flour, commonly known as atta, seems to be a better fit for wheat flour available in the open market and under well-known brands, at least in the near future. The main challenge arises from the decentralized way wheat is processed into flour across India. Banerjee et al. (2011) have proposed a potential solution to simplify the fortification process. This involves integrating the iron-premix with the grain right at the milling stage, eliminating the need for additional steps in upgrading small chakki operations.

Salt

Salt is an excellent vehicle for delivering essential nutrients like iron and iodine due to its widespread use in food preparation. It is a staple consumed universally, making it an ideal choice. The existing infrastructure for salt iodization provides an opportunity to address both iron and iodine deficiencies.

The Salt Iodisation Program in India was initiated in the late 1950s after Professor V. Ramalingaswamy's study identified iodine deficiency as the underlying cause of endemic goiter. The program's primary goal was to prevent and control this condition by distributing iodised salt, which was found to be a cost-effective and practical solution. (Salt Iodiasation Program in INDIA, n.d.)

In 1962, the Government of India launched the National Goiter Control Programme (NGCP) to provide iodised salt to identified goiter-endemic regions. Initially, only public sector entities were authorized to produce iodised salt. With assistance from WHO and UNICEF, iodisation plants were established in Rajasthan, Gujarat, and West Bengal. However, production initially fell short of demand. (Salt Iodiasation Program in INDIA, n.d.)

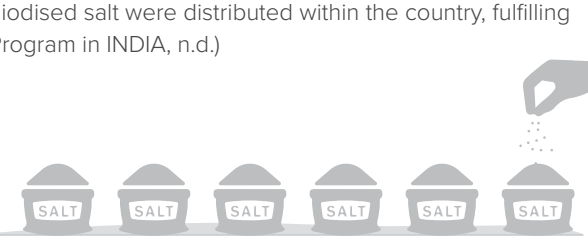
In 1983, the government reviewed the program and introduced policy changes to allow private sector involvement in iodised salt production. A Working Group on Salt Technology, chaired by the Salt Commissioner, was formed to enhance salt production technology. Additionally, a Study Group was constituted in 1984 to address various aspects of the iodisation program. (Salt Iodiasation Program in INDIA, n.d.)

In 1984, recognizing iodine deficiency as a national health issue, the government made a historic decision to iodize all edible salt by 1992. This was included in the Seventh Five Year Plan (1985-1990) and the 20 Point Programme of 1986. (Salt Iodiasation Program in INDIA, n.d.)

The Salt Commissioner's Organization, under the Ministry of Commerce & Industry, is tasked with overseeing iodised salt production and quality, as well as ensuring equitable distribution. In 1992, the program was renamed the National Iodine Deficiency Disorders Control Program (NIDDCP). (Salt Iodiasation Program in INDIA, n.d.)

By December 2005, there were a total of 807 iodisation units, which included 42 refineries, collectively equipped to produce up to 116 lakh tones. Over the years, the production of iodised salt saw significant growth, surging from 2 lakh tones in 1983 to a substantial 48.9 lakh tones by 2005. Notably, approximately 32.3% of the iodised salt output was of the refined variety. In the same year, an estimated 46.4 lakh tones of iodised salt were distributed within the country, fulfilling the dietary needs of 80-85% of the population. (Salt Iodiasation Program in INDIA, n.d.)

Findings from the National Family Health Survey II (1998-99) revealed that



71% **of households were incorporating iodised salt into their diets, & nearly half of them,**

49% **were consuming salt with adequate iodine content.**

In 2005, reports from 12 states indicated that about **73.7%** of the tested samples of iodised salt met the prescribed quality standards.

As part of the program's efforts, 18 manufacturing units for potassium iodate were established across the country. Furthermore, iodised salt was integrated into the Public Distribution System in multiple states, ensuring accessibility for populations falling below the poverty line. (Salt Iodiasation Program in INDIA, n.d.)

Double Fortified Salt (DFS) stands as a noteworthy leap forward in combating iron and iodine deficiencies within the nation. Initially, in the mid-1990s, DFS faced commercial unavailability, primarily attributed to challenges in ensuring the stability of both iron and iodine. However, in the mid-2000s, India's National Institute of Nutrition (NIN) in Hyderabad successfully developed DFS, effectively fortifying it with both iron and iodine. (FSSAI, n.d.)

This innovative fortified food product delivers essential amounts of iodine and iron through the regular diet. Generally, DFS formulations aim to fulfil 100% of the daily iodine requirement and approximately 30 to 60% of the daily iron requirement. The dual fortification of salt with these vital nutrients presents a sustainable solution to combat both iodine and iron deficiencies. (FSSAI, n.d.)

India's National Institute of Nutrition (NIN) has played a pioneering role in developing DFS. The institute has also taken the initiative to transfer this technology to salt manufacturers across the country, providing ongoing quality control support. Additionally, the Micronutrient Initiative has created a version of DFS incorporating encapsulated iron. In 2009, the Ministry of Health and Family Welfare endorsed the addition of iron in double fortified salt at a concentration of 0.8-1.1 mg per gram of salt. (FSSAI, n.d.)

BOX 9

India's Constitution on health and nutrition

The Constitution of India doesn't explicitly state that every person has a fundamental right to Health. However, it does mention public health and the government's responsibility to provide healthcare to its citizens. Having access to proper nutrition and health is considered a basic human right globally. (Sirohi, 2020)

Even though the Constitution doesn't specifically mention the right to health, the Supreme Court of India has interpreted Article 21, which guarantees the right to life, as including the right to health. This means that individuals have the right to receive necessary healthcare for a healthy life. The court has emphasized that the government is constitutionally obligated to offer health services to the people. While the Indian Constitution doesn't directly address health, it does contain provisions showing a commitment to improve the well-being and nutrition of the population. Article 47, for instance, acknowledges nutrition as a crucial human right, necessary for individuals to reach their full physical and intellectual potential. This article falls under the Directive Principles of State Policy, outlining the State's responsibilities regarding nutrition, standard of living, public health, and regulating access to alcohol.

Article 47 of the Indian Constitution reads, " Duty of the State to raise the level of nutrition and the standard of living and to improve public health- The State shall regard the raising of the level of nutrition and the standard of living of its people and the improvement of public health as among its primary duties and, in particular, the State shall endeavour to bring about prohibition of the consumption except for medicinal purposes of intoxicating drinks and of drugs which are injurious to health."

In straightforward language, Article 47 outlines certain main responsibilities of the State. These include elevating nutrition levels, encouraging a decent quality of life, and enhancing public health. This article is based on Socialist and Gandhian principles (Sirohi, 2020). These values aim to promote democracy and secularism, while also making sure that fairness in society, both socially and economically, is upheld. The government uses these principles to shape appropriate programs and projects. The goal is to strive for the improvement of society and the well-being of all citizens.

Ethical Moorings of Large-Scale Food Fortification programmes within the realm of Public Health Policies

Implementing strategies that target entire populations can often be more efficient and cost-effective in reducing sickness and death compared to individual-focused approaches. For instance, programs that encourage behaviours like wearing seat belts or helmets, or prohibiting smoking in public places, can have a significant impact on public health. (Tulchinsky & Varavikova, The New Public Health, 2009)

A widely accepted practice in public health is enriching basic food items like flour, milk, and salt with vital nutrients. While this approach may involve some level of requirement, the overall societal benefit is typically considered more significant than individual preferences. (Tulchinsky & Varavikova, The New Public Health, 2009)

Balancing the rights of the community with those of individuals is a central issue in many debates surrounding modern public health and healthcare, ranging from, for example, treating community water supplies with chlorine to implementing managed care systems for healthcare services. Each situation should be carefully evaluated, taking into account established public health practices supported by evidence, clinical studies, and experiences in other countries. (Tulchinsky & Varavikova, The New Public Health, 2009)

Engaging in public health measures, while protective in nature, can sometimes involve a level of paternalism and coercion. This stems from an ongoing clash between valuing individual freedom (libertarian perspective) and prioritizing the common good (collectivist perspective). The decisions made in health policy hold significant sway over both individuals and communities. (Tulchinsky & Varavikova, The New Public Health, 2009)

The Nuffield Council for Bioethics has outlined an ethical framework that outlines a range of interventions in public health, with varying degrees of coercion. It argues that the most coercive interventions can infringe on "free choice" and lead to a loss of individual autonomy. Coercive measures in public health are typically implemented in response to emergencies, and while they may be well-intentioned and challenging, they are usually temporary. In such cases, the end goal justifies the means. (Tulchinsky & Varavikova, The New Public Health, 2009)

However, implementing mandatory food fortification brings an additional dimension of time and permanence. This program's potential coercion in limiting choice could have long-lasting effects, potentially spanning decades. Another ethical concern with mandatory fortification is fairness, ensuring that the entire population receives equal benefits (or faces equal risks).

It's crucial to avoid a blanket, one-size-fits-all mandatory approach. Different groups may have varying health conditions and responses to specific programs. Therefore, tailoring interventions to specific populations is important for ethical and effective implementation. (Tulchinsky & Varavikova, The New Public Health, 2009)

Still, the proof supporting the effectiveness of public health actions in improving the well-being of individuals and communities is strong.

Presently there are 20 studies over two decades (including 6 from India) conducted on infants, children and women demonstrating the efficacy and effectiveness of fortified rice in improving micronutrient status. These showed reduction in anaemia, increased Hb levels, improved Iron, Vitamin B12, Zinc and multiple micronutrient stores. (Tulchinsky & Varavikova, The New Public Health, 2009)

Nevertheless, it is crucial to always consider these advantages in light of individual rights and the overall well-being of society. Balancing an individual's right to privacy and protection from unwarranted and harmful medical procedures or experiments may sometimes clash with the community's right to shield itself from health risks. This dilemma is central to many activities in public health, which operate on both legal enforcement and humanitarian grounds, relying on education, persuasion, and incentives. (Tulchinsky & Varavikova, The New Public Health, 2009)

The government, acting on behalf of society, is entrusted with the responsibility to work towards the greater good. However, there are limits set by the legal system and mechanisms for administrative appeals to ensure that this authority is exercised appropriately. One of the state's roles is to create conditions that promote health and to ensure that people have access to healthcare and public health services. In public health, there is an ongoing challenge of balancing the rights of individuals with the needs of the community. (Tulchinsky & Varavikova, The New Public Health, 2009)

Sometimes, applying a public health measure for the benefit of some individuals may require implementing it for everyone in a community or nation. This means that the majority of people are subjected to a public health action to protect a minority, without knowing exactly whose life may be saved. In certain cases, a society may need to limit individual freedoms to achieve the goal of reducing disease or injury in the population. For instance, implementing measures like raising taxes on alcohol and tobacco, enforcing speed limits, regulating driving, and mandating seat belt use may restrict individual liberty but ultimately safeguard individuals and the community from potential harm. (Tulchinsky & Varavikova, The New Public Health, 2009)

Certain public health practices involve mass interventions to reduce disease risk in the population. For example, treating community water with chlorine (USA) is a widely accepted and safe measure to protect public health. Fluoridating drinking water (UK) to prevent tooth decay in children benefits everyone who consumes the water, even if it may not directly impact them. Fortifying foods with essential vitamins and minerals is another cost-effective approach for community health, though it may have both supporters and detractors. The inclusion of folic acid in food, which is the most effective way to prevent neural tube defects in newborns, has been mandated by the U.S. FDA since 1998. (Tulchinsky & Varavikova, The New Public Health, 2009)

In a society that values universal access to healthcare, there may be additional incentives in place to encourage individuals to use services that are beneficial for their own health (for example voluntary food fortification in open market in India). This can include things like hospital care, vaccinations, and screening programs (and in this case food fortification). This way, individuals can make choices that align with their own well-being, while still upholding the principle of equal access for all. (Tulchinsky & Varavikova, The New Public Health, 2009)

Thus, in public health, a critical question arises: when is it considered bad practice, or even unethical, to ignore a well-supported intervention backed by solid evidence and practiced in leading countries? Unfortunately, such ethical oversights happen frequently and across various regions. For example, is it morally acceptable to not fortify grain products with folic acid, and salt with iodine? Should there be a recommended immunization program for Europe? Should vitamin D be added to milk? Should women and children receive vitamin and mineral supplements? Should all newborns routinely receive intramuscular vitamin K? (Tulchinsky & Varavikova, The New Public Health, 2009)

The ongoing discussions regarding rice fortification overlook the noteworthy achievement of fortified salt in India. This initiative, spanning 73 years and still continues, has played a crucial role in India's transformation from iodine deficiency to iodine sufficiency. Commencing in the 1950s with iodine fortification, it evolved into a dual fortification program in the 2000s, incorporating iron (Ministry of Health and Family Welfare, 2022). This transition was informed by a comprehensive review of global literature and a substantial body of evidence (as in the case of rice fortification). **It shows that waiting for absolute proof is often not feasible in epidemiology and public health, as it seldom occurs** (Tulchinsky & Varavikova, The New Public Health, 2009). This underscores the importance of a deep and enduring collaboration between public and private sector to continuously assess the accumulating evidence and enmesh nimbleness in public health programmes in order to respond to such evidences comprehensively at low cost.

6 Way Forward

Fortification has been identified as one of the most cost-effective nutrition interventions available, particularly for low- and middle-income countries. Fortification of commonly used food vehicles provides an opportunity for increasing nutrient intake during infancy and for populations at risk of deficiencies without any side effects for the general population. Factors such as infection and inflammation can affect the effectiveness of iron fortification. Additionally, different fortificants yield varying increases in iron levels, and there are notable age and gender differences in prevalence. Still, food fortification leads to rapid improvement in the micronutrient status of a population, and at a reasonable cost, especially if advantage is taken from existing technology and local distribution networks as in the case of India. (Alderman, Gentilini, & Yemtsov, 2023)

Large-scale fortification programs usually face challenges in ensuring vulnerable populations receive adequate fortified products. However, in India, targeted social protection programs, including school meal initiatives, have improved the reach of fortified foods. India's fortification initiatives should be seen with the governments other programmes such as the Anaemia Mukt Bharat (AMB) program, together which aims to distribute fortified foods through various channels, provide supplements and take up social behaviour change campaigns. (Alderman, Gentilini, & Yemtsov, 2023)

The Department of Food and Public Distribution (DFPD) has set standards for food fortification, with a focus on wheat flour, rice, double fortified salt, milk, and edible oil. While benefits from fortification are considerable, they exclude the severely anaemic (since they treated medically). Fortification offers gains in work capacity and cognitive function, but its impact may vary based on individual Hb levels.

The benefit-cost modelling exercise by Qureshy et al. (2023) indicates substantial potential gains from fortification within India's food security programs. Increasing the coverage of PDS rice to the poorest quintiles could amplify these benefits, particularly in terms of cognition. According to this study fortification offers gains in work capacity and cognitive function, but its impact may vary based on individual Hb levels. Qureshy et al. (2023) estimate that since it is not plausible to factor in all the benefits, such as reduced expenditures on social programs and increased tax revenues, a fortification initiatives' advantages are usually underestimated. Additionally, they also do not factor in potential medical cost savings or overall health improvements. Qureshy et al. (2023) also remark that full spectrum of approaches to combating anaemia include programmes such as deworming and malaria control and thus more studies are needed, to explore all possible their combinations with population level food fortification programs and their combined relative effectiveness on various outcomes. Such assessments should ideally track coverage and intakes across different age groups and economic strata, while also monitoring changes in biological markers like haemoglobin levels. Sub-studies could offer further insights into potential changes in cognition and labour productivity associated with fortification efforts. The study encourages a critical evaluation of the assumptions made in the analysis, which can serve as a catalyst for future studies to refine the understanding of food fortification's impact.

Finally, considering Tolerable Upper Limits (TULs) is crucial in designing a safe fortification program. While the risk of exceeding TULs is likely low in countries with a history of fortification, it underscores the need for a comprehensive assessment of the public health and economic implications of scaled fortification programs, including their impact in the context of other fortificants and supplements. Governments are responsible for ensuring that the combination of the food vehicle and the fortificants will be both efficacious and effective for the target group, yet safe for target and non-target groups alike. (Qureshy, Manchanda, & Alderman, 2023)

However, securing popular support may become a challenge. This could stem from a lack of awareness regarding the benefits of fortified foods, both in health and economic terms, or a need for further research in this area. Additionally, limited resources and competing priorities, particularly in low-income countries, can hinder prioritization of food fortification. Developing a comprehensive national fortification program demands significant resources, expertise, and capacity, spanning from assessing the feasibility of fortification to ensuring effective enforcement. (Alderman, Gentilini, & Yemtsov, 2023)

Civil society organizations, including NGOs, associations, healthcare professionals, patient advocates, and individuals with personal experiences of micronutrient deficiencies, play a vital role in highlighting the risks of deficiencies and advocating for adequate food fortification. They can also contribute to transparency efforts and hold industry and governments accountable. These organizations can collaborate with governments and companies to develop and implement fortification campaigns (Tewes-Grad, Gilbert, & Nelson, 2023). The 'Poshtik' platform is one such collaboration.

While stakeholders cannot dictate standards and regulations, they can expedite and assist public sector processes. After integrating Large Scale Food Fortification (LSFF) standards into their operations, stakeholders can contribute insights to public sector fortification initiatives. To ensure trust, such collaborations should be transparent, collective, and independently monitored. Partnerships among public and civic entities are crucial, though it is important to manage and mitigate any conflicts of interest.

Thus, stakeholders external to governments can play a crucial role in advancing food fortification efforts. Depending on the stage of fortification in a country, opportunities for advocacy can range from initiating fortification projects to revising existing standards and ensuring compliance. Stakeholders can contribute by (Tewes-Grad, Gilbert, & Nelson, 2023):

1. **Supporting research:** Providing support for academic research and studies on food fortification is essential for building a foundation in countries. This can involve collaborating with research institutes and offering technical expertise for guidelines and reports

2. **Assisting local proponents:** Working with local champions of food fortification, whether individuals or agencies, is an effective way to promote supportive government policies. Partnerships can actively involve these advocates in their initiatives.

3. **Engaging in dialogue:** Participation in broader discussions about nutrition and food fortification on global and national platforms is important. Stakeholders can share their expertise and technical knowledge in multi-stakeholder alliances and forums.

Conclusion: Towards a Land of Plenty

India has made substantial strides in its food fortification efforts, commencing with the iodization of salt in the 1950s, followed by the fortification of edible oil in the 1960s. This progress extended to pilot projects, targeted initiatives, and large-scale implementations for fortifying rice and wheat with vital nutrients. The establishment of national food fortification standards in 2018, along with the mandatory fortification of rice nationwide in 2022, mark significant milestones.

The Sustainable Development Goals (SDGs) and the 2030 Agenda for Sustainable Development have set forth ambitious objectives to eradicate global hunger and malnutrition. These goals are both inspirational and pose a formidable task, necessitating collective efforts to foster an equitable and inclusive future. SDG17 underscores the importance of global partnerships and multi-stakeholder collaborations in achieving these aims.

In response to this imperative, governments, civil society organizations, donors, private sector entities, and international organizations have acknowledged their role in combating all forms of malnutrition. The Tokyo Nutrition for Growth (N4G) Summit in 2021 witnessed an unprecedented number of commitments, demonstrating a robust collective endeavor throughout the year. India initiated a pilot program and subsequently mandated the fortification of rice within a similar timeframe post-2020. (Ministry of Consumer Affairs, One Year of Announcement of Rice Fortification, 2022).

Food fortification has become a crucial strategy in combating malnutrition, establishing effective public and private partnerships with positive impacts across various societal sectors. This paper specifically emphasizes the importance of population-level food fortification programs in India, with a focus on rice fortification.

Despite notable progress, malnutrition remains a significant concern in India. The collaboration of all stakeholders, including line ministries, experts, and the food industry, has played a pivotal role in addressing this challenge at a national level. The paper highlights the diverse benefits of rice fortification, encompassing improved nutritional status, reduced risk of chronic diseases, and enhanced economic productivity.

Extensive research provides strong evidence for the positive effects of rice fortification, including enhanced iron levels, increased haemoglobin concentrations, and reduced vitamin B12 deficiencies. Fortified rice holds great potential in combatting prevalent micronutrient deficiencies in developing countries, leading to improved health outcomes, especially for vulnerable groups. Nevertheless, further large-scale community-based studies are imperative to definitively establish its efficacy and impact.

While India has achieved significant progress in reducing stunting and anaemia among children in the past decade, current data reveals an increase in anaemia levels among women and children in 16 of 22 States/UTs (NFHS-5) due to insufficient iron, Vitamin B12, folic acid, and other nutrients. Micronutrient deficiency poses a major obstacle to human capital development, labour productivity, and future social and economic growth. In this context, fortifying rice emerges as a viable, preventive, and supplementary strategy for promptly addressing anaemia and vitamin deficiency-induced malnutrition. The attempt to fortify staple foods began with the mandatory iodization of salt in 1962, and the CNNS Report 2016-18 highlighted the success of universal salt fortification by identifying iodine as the sole exception to micronutrient deficiencies in the examined sample.

Effective public health interventions, backed by robust evidence, have demonstrated their capacity to enhance both individual and community well-being. Research in India affirms that fortified rice substantially elevates nutrient levels. However, ethical considerations arise in the implementation of food fortification. Striking a balance between the rights of communities and individuals is a prominent concern in contemporary public health discourse. Mandated fortification raises apprehensions regarding potential coercion, long-term consequences, and ensuring equitable distribution of benefits and risks. Tailoring interventions to specific groups is imperative for both ethical and efficacious outcomes. At times, societies may need to curtail individual liberties to safeguard public health, such as imposing taxes on harmful substances or enforcing safety measures. Ensuring universal access to essential healthcare services is a pivotal ethical dimension in public health, underscoring the principle of fairness.

India's substantial youth demographic, constituting roughly one-third of the population, is often regarded as an asset. However, the prevalence of micronutrient malnutrition poses significant barriers to human capital development, labor productivity, and future social and economic advancement. In response to this challenge, food fortification has emerged as a pivotal measure for ameliorating population health and eradicating nutritional deficiencies. India's national initiatives like PM POSHAN Abhiyan and Anaemia-Mukt Bharat Mission underscore the significance of food fortification (and supplementation) in combatting micronutrient-induced malnutrition. The FSSAI actively advocates and permits fortification of staple foods, including oil, milk, wheat flour, rice, and double fortified salt. Among various fortification interventions, rice fortification emerges as an ideal strategy for closing nutrient gaps and augmenting overall health. However, achieving equitable access to fortified foods necessitates sustained government investment in fortification programs. Notable challenges encompass elevating awareness about fortification benefits, managing costs, ensuring widespread availability, and fostering improved coordination among stakeholders. With dedicated efforts, substantial strides in population nutritional status can be attained through this strategic approach.

We are now steadfastly embarking on a trajectory toward becoming a healthier nation through rice fortification. The impetus for food fortification in India is gaining momentum, and with unwavering dedication and ongoing endeavours, this strategic approach holds the potential for substantial enhancement in the overall nutritional well-being of the populace.

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