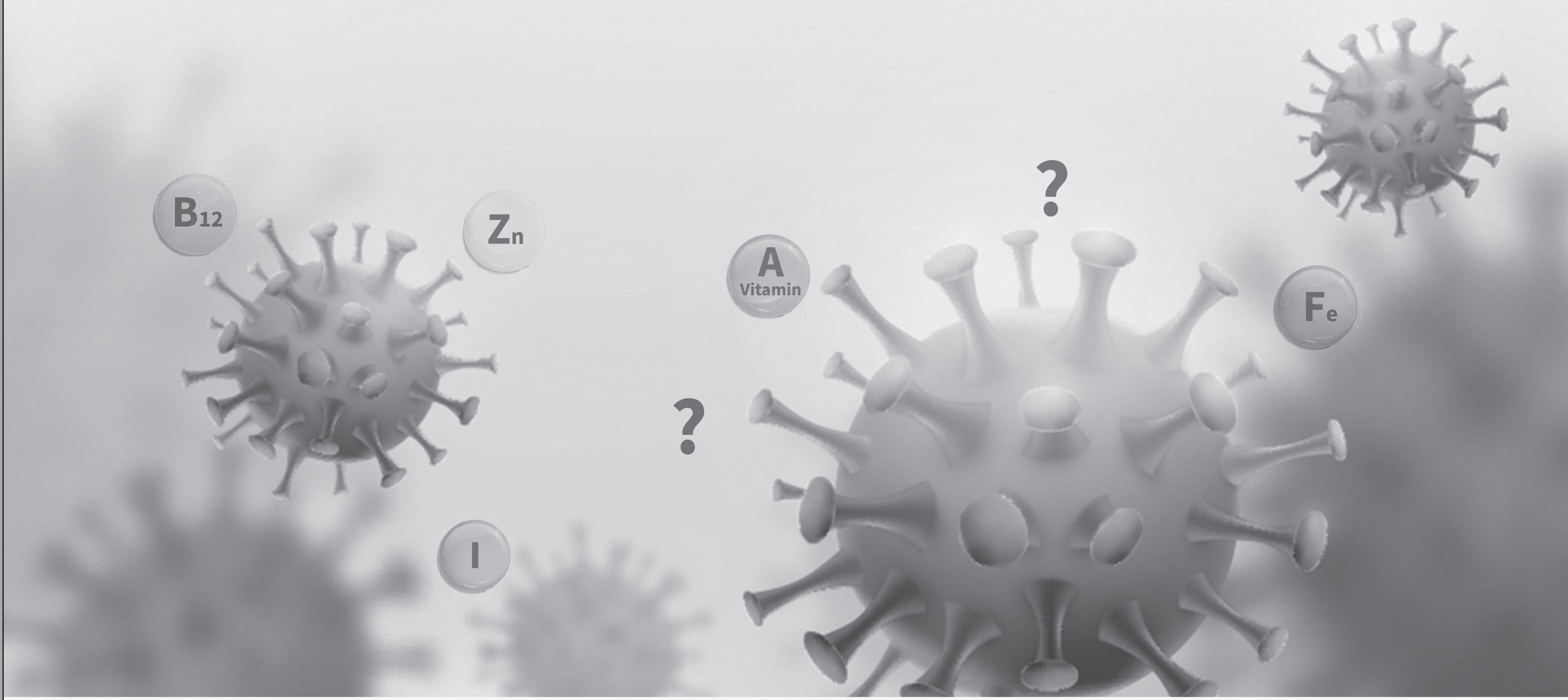
Potential Consequences of the COVID-19 Pandemic on the Status of the Selected Micronutrients in Bangladesh Population



Bangladesh National Nutrition Council (BNNC)
Ministry of Health and Family Welfare
Government of the People's Republic of Bangladesh

Foreword

Micronutrient malnutrition which is known as the "hidden hunger" often coexist with other major form of malnutrition. In Bangladesh during the last two decades there has been notable progress in child nutrition, with reduction of stunting, wasting and underweight, including micronutrient deficiencies. Since the first case of the SARS-COV-2 detected in early March 2020 in Bangladesh, the country has been experiencing significant medical predicament of the pandemic COVID-19. Thus, the impending negative impact of ongoing COVID-19 pandemic on food security, income, employment & other relevant socio-economic factors and compromised programs and services may have diminished impressive gain achieved so far in nutrition.

Underscoring the need to determine the potential consequences of the COVID-19 on the status of micronutrient nutrition and their future outlook, the Bangladesh National Nutrition Council (BNNC) with technical support from partners conducted a contextual appraisal. The appraisal and the projection included key micronutrients which have public health significance in Bangladesh population. A reference level dating back to a past pre-pandemic time (National Micronutrient Survey 2011-2012) was identified and established through the review where the probable decline of the micronutrient status is projected. Furthermore, the review findings were found comparable with preliminary findings of the recently completed NMS 2021, undertaken by National Nutrition Services (NNS) and icddr,b during the covid-19 period. On the backdrop of the COVID-19, the prospective status of the key micronutrients in Bangladesh population suggests a varied outlook. For instance, iodine, zinc and vitamin B12 forecast a "High" risk of the regress towards the reference period. Overall, vitamin A poses a "Moderate" risk of sliding back, whereas the risk in urban-slum areas would be "High". Generally iron poses a "Low" risk of decline worse than the reference level, however, the disadvantaged population in the large cities, Barind-Tract areas and Southern coastal areas exposed to very low levels of groundwater iron are considered in a "High" risk of the decline. Pregnant women are exposed to a "Moderate" risk of decline towards the reference level.

The appraisal undertaken by BNNC to assess the contemporary status, impact of COVID-19 on key micronutrients and future projections is considered a noble and pioneering work not only in Bangladesh but also globally. Based on the findings and specific recommendations for both operational and policy issues, a policy brief has been prepared to help policy makers to plan a well-coordinated, harmonized and mitigating approach for emancipation of a declining micronutrient status in the country.

Pertinent multi-sectorial mitigation measures are recommended to revamp the decline, such as usage of multiple micronutrient fortified rice for the poor population, strict implementation and monitoring of the salt and oil fortification laws and uninterrupted coverage of the vitamin A supplementation for children and iron folic acid supplements for the pregnant mother and the expansion and efficient targeting of the social safety net programs.

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Dr. Md. Khalilur Rahman
Director General
Bangladesh National Nutrition Council (BNNC)

List of Abbreviations

AGP: 1 - Alpha-Acetylated Glycoprotein

ASF: Animal Source Food

BDHS: Bangladesh Demographic and Health Survey

BDT: Bangladesh Taka

BIHS: Bangladesh Institute of Health Science

BNNC: Bangladesh National Nutrition Council

BRRI: Bangladesh Rice Research Institute

COVID 19: Coronavirus Disease-19

EAR: Estimated Average Requirement

EPI: Expanded Programme on Immunization

HIES: Household Income and Expenditure Survey

ID: Iron Deficiency

INFS: Institute of Nutrition and Food Science

IFA: Iron Folic Acid

MICS: Multi-Indicator-Cluster-Survey

MMS: Multiple Micronutrient Supplement

MNP: Micronutrient Powder

NMS: National Micronutrient Survey

NPAN2: National Plan of Nutrition 2

PPM: Part Per Million

RDA: Recommended Dietary Allowance

SARS-COV-2: Severe Acute Respiratory Syndrome- Coronavirus-2

SES: Socio-Economic Status

SQFFQ: Semi Quantitative Food Frequency Questionnaire

SIP: Salt Iodization Plant

SSN: Social Safety Net

UIC: Urinary Iodine Concentration

VAD: Vitamin A Disorder

WHA: World Health Assembly

WHO: World Health Organization

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Executive summary

Since early of the 2020, the World has been experiencing the menace of the pandemic known as the COVID-19-- an infectious disease caused by the virus SARS-COV-2. Being one of the most densely populated countries in the World where nearly 170 million populations reside in a meager 147,000 square kilometer land area, Bangladesh has been among the countries with one of the highest burden of the disease. As of the 3 August 2021, about 18 months after the first detected case in the country, Bangladesh has registered 1,296,093 cases and nearly 21,397 deaths.

Apart from the disruption of the clinical healthcare, the pandemic has been significantly inflicting the non-medical toll on people's employment, earning, food security and food intake. At the time of the first surge of the disease during the April-May 2020, due to the imposition of the first "lockdown" (i.e. "extended general holidays")--the studies reported that there was the profound decline of the household food security both in the rural and urban areas. More than half of the income earners of the household were rendered inactive. Intake of food, particularly among the disadvantaged population plummeted considerably. The first surge of the disease had eased for some months during the winter season, that year (2020). However, during the summer season (2021), the diagnosed cases started to spike again giving rise to the second surge of the disease. The second surge saw even a higher number of cases and deaths, and putting the people in a dilapidated financial situation. Rahman et al (2021) in the most recent study stated that the number of the new poor has been stagnant at 2.45 crores. Moazzem et al (2021) has in another study reported that the new poverty increased by 16.38 million in the recent months. The discourse clearly states that the country has been suffering from significant impairment of people's financial and food wellbeing and the state of the nutritional status of the population is at the stake.

Underscoring the need to determine the stress on the nutritional status due to the pandemic induced food stress-- following the onset of the first surge of the disease, the Bangladesh National Nutrition Council (BNNC) led an appraisal to predict the status of the under nutrition. However, the projection was limited in forecasting the acute malnutrition.

In the wake of the second surge of the disease, with the pronounced impact on people's socio-economic and food wellbeing-- an insult to the status of the key micronutrients (i.e. the hidden hunger) is likely.

Rationale

In the demonstrated context of loss of food well-being in the population for a pronounced duration of time due to the pandemic, it is expected that the status of the key micronutrients would suffer the deterioration. The projected determination of the decline of the micronutrient status and undertaking the corrective measures cannot not be emphasized more.

Primary objective

To understand the status of some key micronutrients in the aftermath of the pandemic COVID-19

Secondary objectives

1. To determine the reference level micronutrients where the possible decline of the micronutrient status is anticipated.
2. To conduct the appraisal using a battery of the contextual elements in relation to the micronutrients.
3. To determine the risk-level of the decline of the micronutrient status using an objective scoring system.
4. To identify the geographical dimension of the projected risks.
5. To recommend specific multi-sectoral actions to mitigate/address the dwindling micronutrient status.

Ideally, a statistical/mathematical modeling of the micronutrient status is the optimum modality. However, for such a statistical projection, the requirements are the serum micronutrient status over multiple temporal time-points, and the uniform set of the co-variables. These enable estimation of the unbiased multivariable regression coefficient and the projection model. However, in Bangladesh, temporal time-series of the nationally representative serum micronutrient data is not available rendering the statistical projection infeasible. Consequently, an attempt was made to undertake a contextual appraisal pertaining to the status of the micronutrients. The process includes the selection of a pre-pandemic reference data and the assessment of risks of the statuses of some key micronutrients falling back towards that level through a lens of specified technical and programmatic appraisal in conjunction with the pandemic-induced diminution in income, food security and food intake.

Methods

Firstly: An appraisal of the studies was done reporting the COVID 19 associated people's loss of work, income, food security and food intake.

Secondly: A narrative literature review was commissioned covering the period (2010-2020) to select the most optimum reference level of the micronutrient status in order to make the projection.

Thirdly: Selection of the key index micronutrients was done considering the public health importance in the Bangladesh population.

Fourthly: A comprehensive appraisal of the pre-pandemic status relating to the micronutrients was done over the following parameters,

a. Quantitative intake of micronutrients
b. Nutrient “need-intake” gaps
c. Relative contribution of the micronutrient sources (plant vs. animal source/total intake of micronutrients)
d. The corresponding serum/urine statuses of the micronutrients
e. Environmental /geological issues which influence the micronutrient status
f. Programmatic appraisal of the relevant micronutrients (pre- and during- the pandemic) and the coverage of the programs.

Finally, upon assessment over these parameters and being deducted through a scoring system, a risk-grading was assigned for regressing back of the status of the micronutrients to the reference level.

Selection of the reference micronutrient level for the projection

A narrative systematic review featuring the national surveys and studies over the pre-pandemic decade (2010-2020) was commissioned. The surveys and studies that reported anemia/ micronutrient status and dietary/micronutrient consumption data were considered for the review. The national micronutrient status survey 2011-12 was selected as the reference level for the projection of the declining micronutrient status on account of the following reasons—1. It is a nationally representative data, 2. Multiple population groups are covered, 3. It considered serum and urine data of micronutrients, 4. Quantitative food intake was measured, 5. Intake of micronutrient was disaggregated by plant and animal sources, 6. Geological factor which has profound influence on some micronutrients was considered; and 7. There was a robust analysis of these data determining the status of the serum/urine micronutrients level.

Over the last decade, there is an improvement of the dietary diversity and dietary quality in Bangladesh. This is evident between 2016 and 2010 (HIES, 2016, 2010) - when the intakes of fishes, meats and eggs marked the increase of +26.8%, +33.3% and +87.3% respectively. There is a scarcity of data as to how this improved quality of diet at the national aggregate level impacted on the micronutrient status prior to the commencement of the pandemic. The most near temporally placed data among the adolescent girls in a rural northern community has shown that the status of the key micronutrients improved compared to the 2011-12 national estimates (JiVitA/ Johns Hopkins cohorts study, 2020; personal communication). Though this improvement is reported in a localized area, any tenable broad based improvement in the micronutrient status that might have occurred due to improving dietary quality over the last decade is likely to be offset as a result of the pandemic –induced socio-economical adversaries.

Consideration of the micronutrients for appraisal

The micronutrients with public health significance in the Bangladesh population-- zinc, iron, Vitamin A and iodine have been included for the evaluation and the projection. Additionally, since the sole dietary source of vitamin B12 is the animal sourced foods, and it is an important hemopoietic nutrient, it has been included for the projection.

Appraisal of the selected micronutrients

Zinc

A very high pre-pandemic deficiency (44% in preschooler & 57% in non-pregnant women) signifies a high vulnerability for the deficiency. The proportion of the 2-3 year-old and 4-5 year-old children not meeting the Estimated Average Requirement (EAR) is 93.4% and 88.1% respectively. The proportion of non-pregnant non-lactating women meeting Recommended Dietary Allowance (RDA) is 0.5-6.4%. Two-thirds (65%) of this insufficient intake comes from plant sources which are poorly bioavailable. Animal-source zinc which is a positive determinant of serum zinc status, has been hit hard by the pandemic, as low income and employment of the population would hinder them to the access to enough animal source foods. Therefore, the outlook for zinc due to the adversaries of the pandemic looks bleak.

Iron

Iron nutrition presents an interesting scenario. The existing data suggest that the status of dietary intake of iron is poor, as just 2.8-5.8% of the preschooler children meet the RDA and none of the non-pregnant women meet the requirement. The proportion of the 2-3 year-old and 4-5 year-old children not meeting the EAR is 42.6% and 52.3% respectively. The proportion of the non-pregnant non-lactating women not meeting the EAR is 65.4%. The contribution of plant origin iron to the total intake was 68.9% (2-3 year old children), 77.6% (4-5 year old children) and 85.6% (19-49 year old women). Amid this stark vulnerability for iron deficiency from the dietary consumption of iron—paradoxically the prevalence of the serum iron status is satisfactory--as the prevalence of iron deficiency (ID) among the children and women ranges 7-10%. The underlying reason for the low ID in presence of grossly inadequate dietary iron is the iron coming from the drinking groundwater sources. The populations of Bangladesh overtly rely on groundwater for drinking, which contains a variable amount of highly bioavailable wholesome iron. The influence of groundwater iron in maintaining the sufficient body iron status is strong and as such, the role of dietary iron has a negligible effect. Therefore, despite there is the significant decline in people's food security and intake due to the pandemic, the majority of the population, especially residing in the rural settings is likely to remain largely unaffected in the iron status. However, in the large cities where iron content in groundwater is typically low (due to chemical treatment of drinking water); and which is home to a large number of the “new-poor” and the disadvantaged population, who are mainly engaged in the urban informal service sectors are in the brink of declined iron status. The Barind-Tract districts with consistently very low level of groundwater iron are likely to decline in iron status due to the fallout of the pandemic. The coastal belt districts with deep tube wells containing a very low level of groundwater iron might have a risk to decline of the iron status. Hence, overall the outlook for iron nutrition in the country gives a mixed scenario.

Vitamin A

The pre-pandemic Vitamin A deficiency is a public health concern-- as ~20% of the preschooler and school age children and 5.3% of the non –pregnant women are suffering from the condition. Accompanying the infection-adjusted high retinol deficiency, the dietary intake of Vitamin A is sub optimum across the population groups. The proportion of the children (2-5 year-old) and non-pregnant non-lactating women not meeting the EAR is 47.8% and 41% respectively. Of the total intake, a very high proportion (children: 70-75% and women: 83%) was consumed from one single source—leafy vegetables with a low bio-conversion efficiency. Intake of animal source foods and the intakes of leafy vegetables are the positive and negative determinants of serum Vitamin A status respectively. The effect of the traditional plant based food systems is limited; and has been failing to elevate the serum Vitamin A status over the last decades.

However, since 2015, the country has scaled up the mandatory use of the Vitamin A fortified edible oil program nationwide, using the retinyl palmitate – a highly bioavailable preformed Vitamin A compound. Nonetheless, recent reports suggest some issues with the program. Such as only 41% of the non-bottled oil (non-bottled oil holds a 2/3 market share) are fortified; and among them (non-bottled), just 7% meet the standard requirement of Vitamin A fortification.

Hence, the present evaluation suggests-- on one hand there is a highly potent oil fortification program has been operational over 6-7 years with a potential for elevating the Vitamin A status. On the other extreme, the program suffers from some quality and coverage issues. Due to the pandemic-induced economic hardship, many people are likely to adapt to the increasing use of the non-bottled oil which is linked with the substandard fortification practices and standards.

Hence, a mixed outlook is apparent for the projection of the Vitamin A status.

Iodine

Iodine with very high pre-pandemic subclinical inadequacy-- 33.8-40% in school age children and 38.6-42.1% in the non-pregnant women pose a major threat to the public health in Bangladesh, and clearly indicates the vulnerability for the deficiency. Compounding this, usage of the adequately iodized salt (>15 parts per million) has been remaining stagnant at around 56-58% over the decades. Up to 37% of the poorest households use cheap, open salt. Household food insecurity, poverty and the high cost of the packet salt are some of the negative determinants of iodine nutrition in the population.

During the pandemic, the GoB has ensured the unrestricted movement of the commodity across the country and there was no reported issue of the premix (KIO3) procurement. In addition, the GoB has very recently introduced the new salt law which has the provision for the tighter regulation and monitoring to improve the quality and coverage of the program. Nonetheless, with a stubbornly stagnant low use of the adequately iodized salt, and with the advent of the pandemic-induced poverty, lack of employment, it is envisaged that more people would resort to buy much cheaper open and /or industrial salt (non-iodized). Despite the new salt law has been passed, it might take some time to get fully operational across the country. Appraising all these issues, the immediate outlook for iodine looks bleak.

Vitamin B12

The pre-pandemic deficiency of vitamin B12 is high (22%) among non-pregnant women and 26% in pregnant women. Household food insecurity and poverty are the negative determinants of the poor status. Since, the source of vitamin B12 is only the animal source foods—the pandemic induced economical adversaries are likely to cut down the intake of the same in the disadvantaged population. Hence, the pandemic portrays dismal fallout of the vitamin B12 status.

Results

After the evaluation of the micronutrients using the predefined lens for the appraisal; and applying a scoring system, the following risk-attribution is assigned on the micronutrients for regress back to the reference level.

Table 1: Risk-projection of the key micronutrients

	Micronutrients	Risk-category
1.	Zinc	High
2a.	Iron (predominantly rural settings)	Low
2b.	Iron (pregnant women)	Moderate
2c.	Iron (Large cities, Barind Tract, Southern coastal areas)	High
3.	Vitamin A	Moderate
4.	Iodine	High
5.	Vitamin B12	High

General recommendations

1. Establish a system to better manage the availability of and access to the animal source foods (ASF) –i.e. producers can sell & poor can access to in a mutual win-win matter at the time of the calamities like COVID-19 pandemic [Short & Mid-term].
2. Strict monitoring and implementation of the concerned fortification/supplementation laws [Ongoing]
3. Explore the ways for the improved targeting of the Social Safety Net (SSN) [Short-term].
4. Coordination among the concerned departments on the various micronutrient interventions (i.e. fortification, bio-fortification, supplementation)--so the needs for the micronutrients are met and not exceeded [Mid & Long-term].
5. Provision of the Multiple Micronutrient Supplement (MMS) for pregnant women and adolescents, Micronutrient Powder (MNP) for children in poor, new poor and food insecure populations [Short & Mid term].

Specific recommendations

Zinc

1. Expansion of the SSN with allocation of the multiple micronutrient-fortified rice containing zinc in the food basket. This intervention may be expanded for poor population e.g. urban slum poor/new poor [Short-term].
2. Enabling the access to the animal source foods (ASF) for poor income population [Short & Mid-term].
3. Improved varieties of zinc bio-fortified rice to undergo further scientific assessment and promotion [Mid & Long-term].

Iodine

1. Prompt and effective implementation of the salt law 2021, including strict countrywide monitoring, especially in low performing divisions [Short & Mid-term].
2. Temporary provision of iodized packet salt in the food-basket for the poor/new-poor population [Short-term].

Vitamin B12

1. Enabling access to the ASF for the income poor/new-poor [Short-term].

Vitamin A

1. Heightened monitoring of the oil fortification standards and penalty for breeches [Short & Mid-term].
2. Enabling the access to the ASF for the income poor/new poor [Short-term].
3. Temporary provision of Vitamin A fortified bottled oil in the food basket for the poor/new poor
4. Urban slums need additional focus on the recommended activities [Short & Mid- term].

Iron

1. MMS/IFA should have uninterrupted supply all over the country [Short-term].
2. No major intervention (in the predominantly rural settings) is required
3. For large cities, low groundwater iron containing Barind Tract districts or in the coastal belt areas (where iron content is very low in groundwater), expansion of and inclusion in the SSN or other similar schemes of the multiple micronutrient-fortified rice containing iron [Short & Mid-term].

1. Introduction

Bangladesh, one of the most densely populated countries in the world has been affected by the pandemic – Coronavirus Disease (COVID-19) over the last eighteen months; and is ranked among the countries with the highest number of the detected cases.1 Since, the detection of the first case with the disease in early March 2020, the nation experienced the first surge of the cases in June-July, 2020. There was a steady decline of the disease during the following months resulting in low case burden in the months of January-February, 2021. However, since March 2021 the country has been experiencing the second surge of the disease.[1] As of the 3 August 2021, the detected cases in the country has registered to 1,296,093 and 21,397 deaths. The COVID-19 has been wreaking substantial non-medical adversaries regarding employment, food consumption and food security. There is a clear outcome of these adversaries on the nutritional status of the populations globally. Bangladesh – a large developing country with a population of 165.43 million [2] is likely to face an adversary on the same.

1.1 General overview of nutritional status in Bangladesh population

Bangladesh is a small county with a huge population. Two decades back, more than half of the children and women had suffered from a single or multiple forms of malnutrition. Since then the country has made impressive progress in tackling under nutrition. The recent nationally representative survey estimated that 31% of children under 5 years-old were short for their age (i.e. growth stunted), while 9% were severely stunted. The survey further estimated that 8% of children under 5 were thin for their height, or wasted.[3] Status of under nutrition often coexist with the other major form of malnutrition—i.e. micronutrient malnutrition which is often known as the "hidden hunger". Micronutrient malnutrition in Bangladesh was at a staggering scale before the turn of the century. Since, then some improvement of the status has been observed. However, still some of them exist at the magnitude consistent with the public health concern. The nationally representative micronutrient survey 2011-12 revealed high prevalence of the subclinical deficiency of Vitamin A (20.5-20.8%), Zinc (44-57%), iodine (38-42%), vitamin B12 (22%), vitamin D (40-70%) according to different population groups.[4]

1.2 Existing micronutrient deficiency prevention programs

To emancipate the high burden of micronutrient deficiencies, the government of Bangladesh has been implementing several programs for the decades. Bangladesh initiated the periodic Vitamin A supplementation program for children since 1973. From 1995, the program was housed within the national immunization day (NID), a successful nationwide platform. It supplemented the high potency capsules (100,000 IU for children 6-12 months and 200,000 IU for children 12-59 months old) every six months. The coverage of the program has been high with recent estimates above 90%. Bangladesh piloted the fortification of edible oil with Vitamin A in late 2011. The 'National Edible Oil Fortification Law', aiming for 100 % fortification of refined edible oil with Vitamin A was enacted in 2015. However, its impact on VAD is not known yet on a nationwide scale. In the country, the Universal Salt Iodization (USI) program has been operational for more than two decades. However, the coverage of the adequately iodized salt (≥20 parts per million (ppm)) at the retailer level is 66.4 % and at the household level is 57.6 %, which is suboptimum.[4] The program has been facing numerous challenges regarding the coverage and quality issues. Iron–folic acid (IFA) supplementation program for pregnant women has been operational for several decades aimed at controlling and managing iron deficiency and anemia. IFA supplements (60 mg Fe and 400 µg folic acid daily) are provided to pregnant women from the second trimester until 90 days after delivery.[5] Currently, there is no large scale nutritional program for zinc- except for the zinc supplementation as a part of the diarrhea treatment. However, this is a medicinal use of zinc and irrelevant in the public health aspect. Zinc fortified rice (industrial and bio-fortified) has been gaining interest. The government in partnership with World Food Programme and other collaborating partners has been implementing the zinc-fortified rice (i.e. fortified rice kernels) for the ultra-poor families under the social safety net (SSN) programs. This fortified rice kernels look, taste and cook like ordinary rice but are enhanced with six essential vitamins and minerals: Vitamin A, Vitamin B1, Vitamin B12, Folic Acid, Iron and Zinc. They are mixed with ordinary rice at a ratio of 1:100.[6] There is an intention for commercial scale up. Led by the Bangladesh Rice Research Institution (BRRI) in partnership with Harvest plus – development of zinc bio-fortified rice is gaining the momentum. Several varieties of the high yield zinc bio-fortified rice—BRRI- 74, BRRI-84 and BRRI-100 have been developed. The zinc bio-fortified rice is promising to mend the very high burden of zinc deficiency in the Bangladesh population.

1.3 GoB programs for alleviation of poverty –Social Safety Nets (SSN)

Safety net programs in Bangladesh have been contributing to the decrease of poverty and susceptibility by addressing a range of population groups through various kinds of assistance. These include the provision of income incentive for the elderly, widows and persons-with-disabilities, creating temporary employment for men and women, and promoting the healthy development of young mothers and children. The modalities of the support are--cash allowances, public works, and education and health supports for poor and vulnerable households, which aim to contribute to the fight against poverty and improving human capital. The government has under its repertoire—

1. Old age allowance
2. Allowances for Widow, Destitute and Disserted women
3. Allowances for financially insolvent disables
4. Public works e.g.—a. Employment generation programs for the poorest b. Food for work/ Work for money and Test Relief

5. Vulnerable Group Feeding- A humanitarian program that provides food transfers to the poor during disasters and major religious festivals; and
6. Conditional cash transfer--The programs, e.g. Towards a Child Benefit Scheme which invests on child development during pregnancy and the early years.

The programs being aided by the development partners have been performing well. In the wake of the first surge of the COVID-19 pandemic, 6.86 billion Bangladeshi Taka has been delivered digitally to cash transfer recipients, of which 58% of the funds went to women (as of June 2020). Despite a fair amount of allocation, targeting was a challenge. Despite the range of interventions, as of 2019, only around one-third of the poor population were covered by safety nets, primarily because of the challenges in identifying vulnerable households, denoting the lack of pro-poor targeting of social programs. There are duplicative efforts across programs, and the old-fashioned administrative systems limiting the ability to respond to the needs of the vulnerable in a timely manner and to be fully reachable and answerable to citizens.[7]

1.4 Effect of COVID-19 on income, employment and household food insecurity in Bangladesh

A nationally representative survey in the country reported, in the first month into the first “lockdown”, compared to the Pre-COVID-19 period (February 2020) overall, 63% of the main-earners in families were rendered jobless. As the survey reported, compared to the reference time, income plummeted by 75% in urban slums and 63% in the rural settings. Some 71 % of the urban respondents and 55% of rural respondents experienced uncertainty of livelihood. Proportion of households recording decreased food intake was 47% and 32% in urban slums and rural areas respectively.8 A profound effect of the COVID-19 pandemic in the arena of employment is the loss of jobs. Urban informal economy incurred the loss of 6.78% of jobs. High level of job loss occurred during the immediate period of the pandemic (11.1- 20.5 million). Loss of jobs in relation to overseas employment in the form of returnee migrants were 0.4 million during March-September, 2020.[9]

Hamadani et al with a pre-post study design has disentangled a precise effect of the COVID-19 related “stay-at-home” advice on household food insecurity and earnings of the families in a rural setting of Bangladesh. The authors estimated that the median monthly income of the same families dropped from US$212 (before COVID-19) to $59 during lockdown ($p<0.0001$). Before the COVID-19 the moderate and severe form of household food insecurity was 5.6% and 2.7%, which rose to 36.5% and 15.3% respectively during the lockdown; and 70% of the households experienced any form of food insecurity .[10] Another study in a rural and an urban slum setting, which gathered data over the first month into the lockdown, estimated that 90% of the households were experiencing any form of household food insecurity.[11]

1.5 Effect of the COVID-19 on the escalating food prices and poverty

The imposition of the first "lockdown" during March 2020 resulted in significant impasse in people's movement, economic activities and restricted the supply chain of the necessary consumables. This led to the price hike of the essential food items (Table 2). An additional nationwide lockdown ensued in April, 2021 in the wake of the second surge of the pandemic with the bleak prospect of further spiraling of goods price.

Table 2: Escalating food prices (January 2020-April 2021) [12]

Foods	Change (%) in April 2020 compared to January 2020	Change (%) in April 2021 compared to April 2020	Change (%) in May 2021 compared to April 2020
Rice Aman (fine)	12.24%	12.73%	12.73%
Rice Aman (coarse)	41.38%	9.76%	7.32%
Rice Boro (coarse)	33.33%	12.5%	7.5%
Pulse (khesari)	-22.03%	47.83%	47.83%
Edible oil (soybean)	4.5%	26.80%	27.84%
Broiler chicken (farm)	46.15%	-8.77%	-13.45%

The Table 2 shows the hike of price of some essential food stuffs. During the first surge of the pandemic (April 2020), the price of coarse rice (Aman and Boro) increased by 33.3-41.4% compared to the pre-pandemic time (January 2020). At the onset of the second surge (April 2021) the price of these varieties further hiked by 9.8-12.5% relative to the period of the first surge (April 2020). The pulse (khesari), the other staple food for the Bangladeshis saw a drop in price (-22%) during the first surge (April, 2020). However, during the second surge (April, 2021) the price skyrocketed by 48% relative to the price during the first surge (April, 2020). Soybean oil price saw an increment of 4.5% during the first surge (April, 2020) compared to the pre-pandemic time. It sharply rose by another 27% as the second surge began (April, 2021). The poor man's affordable animal food—the broiler chicken saw an exponential rise in price at the time of the first surge (46.1%). During the second surge the price dropped somewhat but still remained at a significantly higher level relative to the pre-pandemic time.

The loss of financial affordability in tandem with rising price of the common food stuffs has the implication on nutrition. In this particular scenario, a steep rise in rice price and the common animal food implies that the poor people might cut back the consumption of the staple with a negative effect on energy. The other possible scoping mechanism could be significant cutting off the animal source foods and just to continue on the cereal (i.e. rice) to quench the hunger. The modification has significant implication on micronutrient status. The low intake of animal food will reduce the intake of higher bioavailable micronutrients, e.g. zinc, iron. On the other hand, the subsistence reliance predominantly on cereals implies the poor bio-availability of the micronutrients, as rice is the overwhelming source of phytate (the micronutrient chelator) in Bangladeshi traditional diet. [4]

The Power and Participation Research Centre (PPRC) and the Brac Institute of Governance and Development (BIGD) conducted the recent study on the coronavirus' impact on people's income and poverty. The Rapid Response Research (RRR) carried out a panel survey in March, 2021 on over 6,000 people living in rural and urban slums. The PPRC and the BIGD reported that over the last one year, a portion of the new poor was able to come out of poverty. However, around 2.45 crore people still suffer in poverty. The survey further reported—the informal loans in households in cities increased by 86% in one year. The urban people were forced to cut food expenditure by 17%; and 9.8% people who migrated from the cities did not return. The rate of extreme poverty went up by 4% in March this year from February . [13]

1.6 Income, food security, micronutrient intake and micronutrient statuses are associated

Low family income/wealth status is associated with household food insecurity. [14, 15] Household food insecurity in turn is associated with low dietary diversity [16] suggesting the monotonous, nutrient-poor and cheap foods. Household food insecurity is further associated with micronutrient intake and/or status. Studies have suggested that the micronutrient intake and the serum status are lower in food insecure households compared to food secure households.17,18 Hanson et al has suggested that food-insecure adults consumed fewer vegetables, fruits, and dairy products than did food secure adults and had lower intake of Vitamin A and B-6, Calcium, Magnesium, and Zinc. [19]

1.7 Compromisation of maternal nutritional services and counseling

Distribution of iron-folic acid supplementation for the pregnant women and the counseling during the Anti natal checkups (ANC) is the mainstay of nutritional service for pregnant women. The figure 1 clearly depicts that, both these services took a plunge during the quarter January-March, 2020 at the onset of the first surge of the pandemic. Thereafter an improvement was observed till the mid of the quarter October-Dec 2020. However, as the second surge of the disease heralded, the decline in the uptake of the services was observed during January-March 2021.

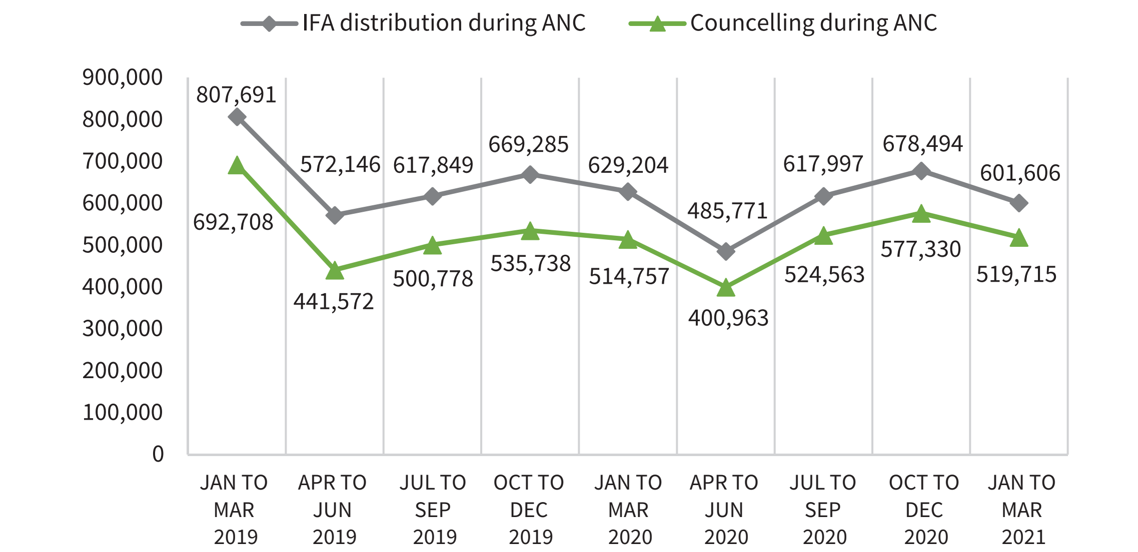


Figure 1: Compromisation of maternal nutritional services and counseling

1.8 Potential threat on micronutrient status in Bangladesh

The figure 2 depicts an ominous impression of the gravity of malnutrition in the aftermath of the COVID 19. The graph shows, since the first surge of the disease in April-June 2020 the cases of admission with severe acute malnutrition (SAM) has increased in an exponential manner. As the second surge has onset, the admitted cases became 6-times during the January-March 2021 quarter. Children with severe acute malnutrition often have micronutrient deficiencies.[20] This is an indirect évidence of the possible dent on the status of micronutrients due to the effect of the pandemic.

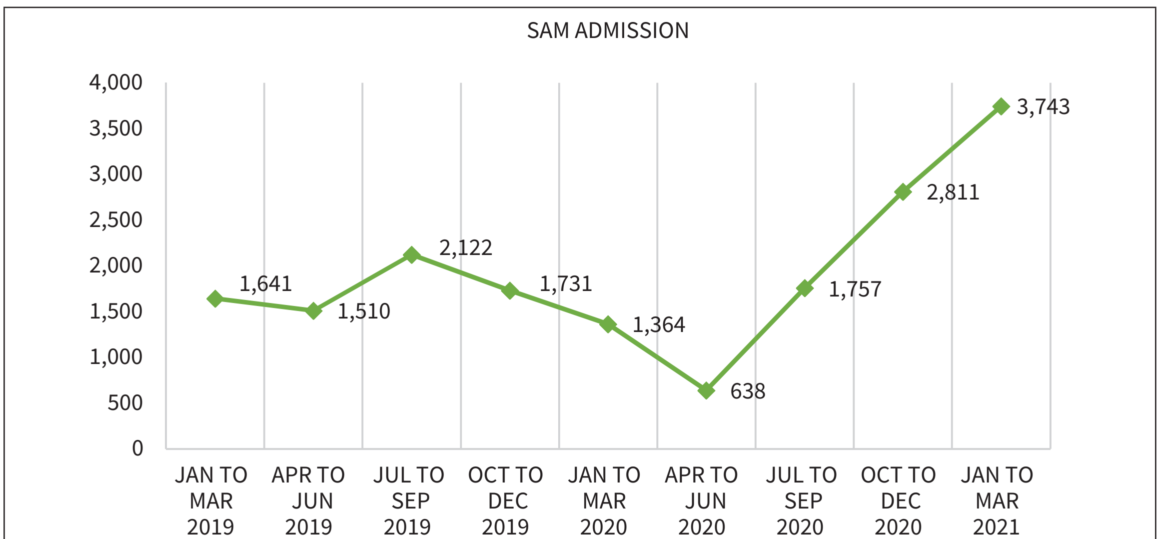


Figure 2: Admission of the cases of SAM (Jan 2019-March 2021)

2. Rationale

The pandemic has affected adversely on people's income, employment and food security in Bangladesh. The above evidence heightens the concern that the low financial and food wellbeing might have a damaging effect on the micronutrient status of the population of Bangladesh. On the other hand, highlighting the significance of the COVID-19 associated fallout of under nutrition in population, Bangladesh National Nutrition Council (BNNC) -- the prime institution of the country's nutritional policies led an appraisal on the projection of under nutrition.[12] The assessment was limited to the projection of acute malnutrition.

With the advent of the COVID-19 with the potential harm to the nutritional, especially micronutrient status in population, a projection of the micronutrient status cannot be emphasized enough in order for inculcating the mitigation measures. Status of population-level micronutrients is reported by the serum level (i.e. biomarkers) and it is founded on multiple factors- dietary intake, dietary type, infection burden, environmental/geological issues and the micronutrient programmatic matters. Assessment of nationally representative micronutrient status is expensive, logistically challenging, and thus difficult to conduct in the resource-poor settings. Projection of micronutrient status for a country ideally would require the nationally representative serum micronutrient data over a number of time points alongside the data of the relevant covariates to develop and standardize a predictive mathematical model. Due to the lack of the appropriate temporal data in the resource-poor settings, such a mathematical/statistical predictive model is difficult to generate, and there is a scarcity of the same in the existing literature. Hence, the present study attempted to conduct a contextual review of the micronutrient status in Bangladesh along with the appraisal of its intimately linked elements in order for a qualitative risk-appraisal of the declines of some key micronutrients in the prevailing context of the COVID-19.

2.1 Primary objective

To understand the status of some key micronutrients in the aftermath of the pandemic COVID-19

2.2 Secondary objectives

1. To determine the reference level micronutrients where the possible decline of the micronutrient status is anticipated
2. To conduct the appraisal using a battery of the contextual elements in relation to the micronutrients
3. To determine the risk-level of the decline of the micronutrient status using an objective scoring system
4. To identify the geographical dimension of the projected risks
5. To recommend specific multi-sectoral actions to mitigate/address the dwindling micronutrient status

3. Methodology

3.1 General procedure

A detailed contextual appraisal was undertaken to understand the micronutrient status of the pre-pandemic period and the core factors including the intake profiles and the micronutrient programmatic and structural issues. The process includes selection of a pre-pandemic reference data and assessment of risks of the statuses of some key micronutrients falling back towards that level through a battery of specified technical and programmatic appraisal in conjunction with the pandemic-induced diminution in income, food security and food intake.

Firstly an appraisal of the studies was done on how the COVID-19 associated limitations affected the income, employment, food security and food intake in Bangladesh populations.

Secondly, a brief narrative literature review was done of the studies and the national surveys conducted over the preceding decade of the COVID-19 pandemic (2010-2020). The primary intent of the review was to select the most optimum reference survey/study to assist in the projection of the pandemic-induced micronutrient status. In the process a general principle for the projection was identified.

Thirdly, the index micronutrients for appraisal were selected taking into consideration the public health importance in the context of the country.

Fourthly, the appraisal of the pre-pandemic status of the selected micronutrients was done considering the quantitative intake of micronutrients, nutrient need-intake gaps, intake relative to the reference intake, relative contribution of sources (plant vs. animal source/total intake); and the accompanying serum/urine statuses of the micronutrients. The appraisal considered the environmental/structural issues relating to specific micronutrient which determine its status. A comprehensive assessment of the programmatic issues was included for some relevant micronutrients (pre- and during the pandemic).

Finally, based on a thorough assessment of these parameters, a scoring system was applied; and some provisional "risk-grades" were deducted to project the COVID-19 associated probable fallout of the selected micronutrients status regressing to the reference level.

3.2 Literature review of the studies and selection of the reference data for the projection

A pre-post comparative assessment of the impact of the COVID-19 on the serum micronutrient status is the method of choice. However, during this unfavorable circumstance, data is unavailable on the population-level micronutrient status in the aftermath of the COVID-19. Ideally, the optimum appraisal of micronutrients status of a nation requires the assessment of the serum micronutrients level and the quantitative micronutrient intakes considering differential absorption potential (plant vs. animals sources) on large/nationally representative samples. To appraise this, a narrative review was undertaken of the large national surveys and studies conducted over the pre-pandemic period (Figure 3). A number (n=7) of the nationally representative surveys were considered which stated the dietary/micronutrient intakes and/or serum micronutrient status.

Further, a brief literature review of Bangladesh-based studies was undertaken encompassing the period of 2010-2020 on the PubMed database.

Inclusion criteria were:

a. The reporting of food/nutrients intake (quantitative or qualitative) and/or,

b. Serum micronutrients/anemia status.

The words used in the search were- [Dietary intake + Micronutrient status+ Bangladesh] which returned 35 papers. Among the papers 10 were reporting the partial or comprehensive pertinent data according to the inclusion criteria; and thus were included for the appraisal. Additionally, two ongoing/unpublished studies concerning dietary intakes and/or serum micronutrient status were considered for the appraisal. So, the review included 19 studies and the national surveys (Figure 3, Table 3).

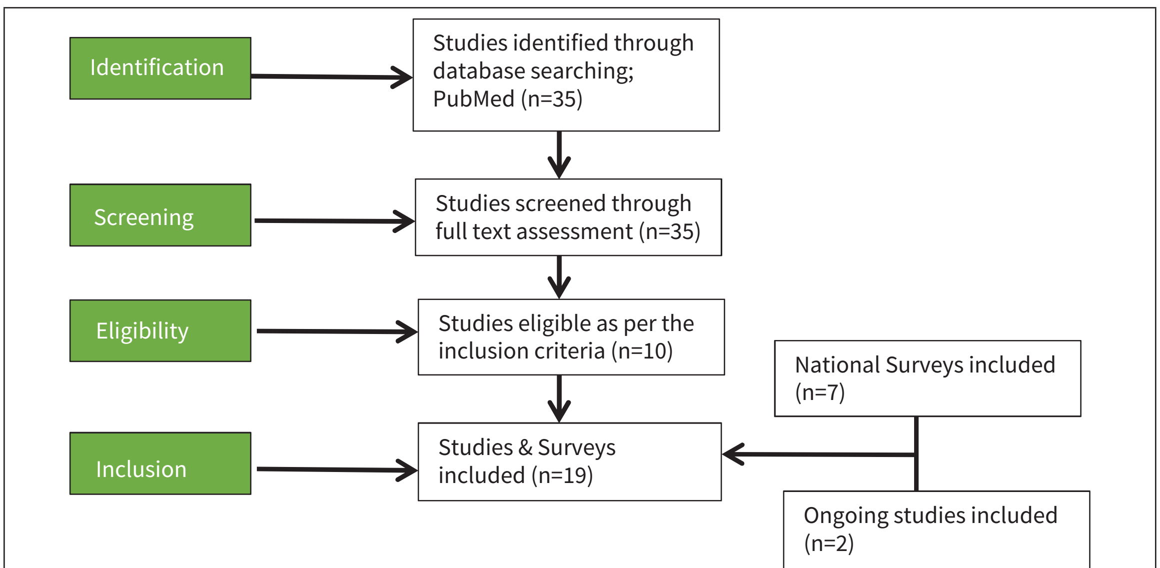


Figure 3: PRISMA flow diagram of the studies and surveys to select the reference data

Among the localized studies—G. Ara et al [21], Nguyen et al[22, 23], Stewart et al[24], Hossain et al [25], and Mustafa et al [26] (Table 3) do not meet both of the two key parameters of appraisal - serum micronutrients and the quantitative micronutrient intakes. Major nationally representative surveys, e.g. Bangladesh Demographic Health Surveys 2017, 2014, 2011 [27,28,29] have not measured the serum micronutrients or the quantitative micronutrient intakes—but the qualitative dietary intakes (Table 3). The BDHS 2011 [29] reported the prevalence of anemia. The Household Income and Expenditure Surveys 2016, 2010 [30, 31] reported the quantitative food intakes at the household level and not the quantitative micronutrient intakes or the serum micronutrient statuses. The Multi-Indicator-Cluster-Survey 2019 reported only the qualitative dietary intakes.[32] By far, the National Micronutrient Status Survey 2011-12 [4] reported nearly all the considered parameters for the appraisal on multiple population groups over a nationally representative scale.[4]

Table 3: Contemporary National Surveys and Studies Concerning Micronutrients in Bangladesh over the last decade (2010-2020)

Surveys/Studies	Serum micronutrients	Anemia	Quantitative Micronutrient Intakes	Quantitative food intake	Qualitative food intake
National Surveys					
MICS, 2019 [32]	×	×	×	×	√
BDHS, 2017 [27]	×	×	×	×	√
HIES, 2016 [30]	×	×	×	√	×
BDHS, 2014 [28]	×	×	×	×	√
NMS, 2011-12 [4]	√	√	√	√	×
BDHS, 2011 [29]	×	√	×	×	√
HIES, 2010 [31]	×	×	×	√	×
Local/Sub-national studies/surveys					
Iqbal et al, 2019 [33]	NR*	√	√	√	√
G. Ara et al, 2019 [21]	√ (Zinc only)	√	×	×	√
Nguyen et al, 2017[a] [22]	×	×	√	√	×
Nguyen et al, 2018[b] [23]	×	×	√	√	√
Stewart et al, 2019[c] [24]	√	√	×	×	×
McCormick et al, 2019[d] [34]	√	√	√	√	×
Sanin et al, 2018 [35]	×	×	√	√	×
Mustafa et al, 2020 [26]	×	×	√	×	×
Leyvraz et al, 2016 [36]	√	√	√	√	×
Hossain et al, 2019 [25]	×	√	×	×	×
INFS (2017-18), (Personal comm.)	×	×	(Personal Comm.)	(Personal Comm.)[e]	NR*

Surveys/Studies	Serum micronutrients	Anemia	Quantitative Micronutrient Intakes	Quantitative food intake	Qualitative food intake
JiVita/Johns Hopkins University Cohort for adolescents (2019), (Personal Comm.)	√	√	NR*	NR*	NR*

*NR (Non-Reported): The pertinent indicator either absent or unpublished
[a]data-period (2015-16); [b]data-period (2015); [c]data-period (2012-13); [d]data-period (2009-2014); [e]Animal-sourced foods;

Despite being older to some extent, the survey is the most inclusive for an optimum appraisal of the micronutrient status of the populations. Interestingly, when this national survey is compared with some recent (conducted shorter interval prior to the pandemic) studies, the intake estimates of the micronutrients seem not largely different and reasonably consistent accounting for the varied designs (national survey vs. localized studies; SQFFQ vs. 24-hour-Recalls) and population structures of the studies (Table 4).

Table 4: Comparative intakes of the selected nutrients between the NMS 2011-12 & the recent pre-COVID-19 studies

Survey/Studies	Settings	Data collection	Vitamin A (µg RAE/d)	Iron (mg/d)	Zinc (mg/d)
NMS 2011-12* [4]	National Survey	2011-12	270.4	4.1	3.1
Rahman et al, 2019[a] [37]	Rural central-north sub district	2018	299.0	3.6	5.3
Iqbal et al, 2019[b][33]	Dhaka slum	2016	472.5	3.8	2.8
Sanin et al, 2018[c] [35]	Dhaka slum	2016	63.2	1.59	1.27
Mustafa et al, 2020[d] [26]	Dhaka slum	2016-2018	57.8	2.2	1.3

*Children aged 24-59 mo
[a]Children aged 24-59 mo
[b]Children 24-36 mo old
[c]Children 12-24 mo
[d]Children 12-18 mo; Length-for-Age Z-score<-1

3.2.1 An appraisal dietary and micronutrient intake

Over the last several years, Bangladesh has demonstrated an improvement in dietary quality alongside the increase of people's purchasing capacity. The Household Income and Expenditure Survey 2016[30] reported that at the national level there was a considerable increase in the consumption of meat (+33.3%), eggs (+87.3%) and fishes (+26.8%) compared with the preceding round.[31] Over the same period the intake of cereals such as the consumption of rice dropped by 13.3%. However, this data pertains to the average person value (i.e. person average at household) and not accounted for particular population groups, which is a limitation. These temporal HIES data clearly indicate a qualitative improvement of food intake at the aggregated household level. In consistent with the HIES data from 2010 to 2016, three other large scale surveys have shown the qualitative improvement of food intake in Bangladesh population (Figure 4).

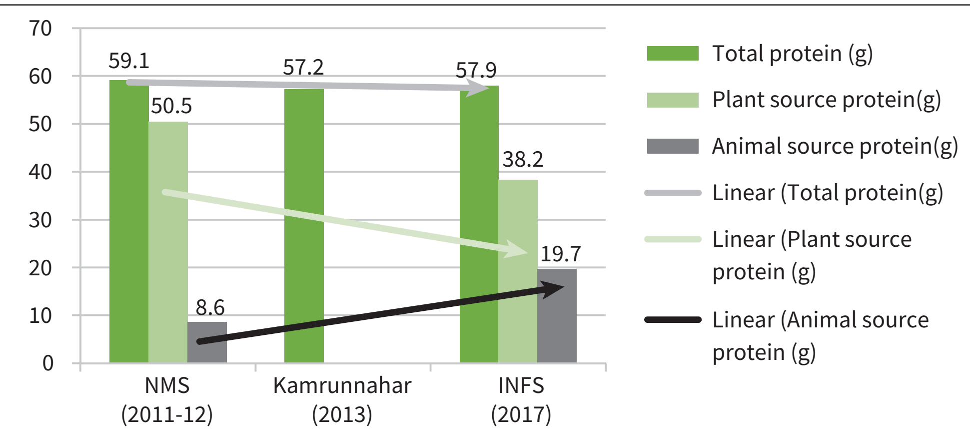


Figure 4: A trend of intake of protein (g/day) by sources (plant vs. animal) across three temporal time-points (2011-12 to 2017)

The intake of protein in adult population was 59.1 g/day, 57.2 g/day and 57.94 g/day in the NMS 2011-12 [4], Kamrunnahar et al (2013) [38] and the INFS (2017) [personal communication] surveys, which essentially do not represent any significant change. However, the intake of animal source protein showed large increment from the NMS 2011-12 (8.64 g/day) to the INFS 2017 survey (19.70 g/day). With gradual decrease in the intake of the plant based protein over these time-points, it is clearly demonstrating the qualitative improvement of diet.

Concomitant to the demonstrated improvement of the quality of diet (i.e. animal source foods and animal source proteins), an appraisal is essential for some pertinent micronutrients (Table 5).

Table 5: A comparison of the quantitative intakes of energy and two key micronutrients (2011-12-to-2017)

Nutrients	NMS 2011-12 [national]	BIHS (2015) (rural)	INFS/FAO (2017) (Rural +Urban)
"Older" adolescents	Age (15-18 years)	Age (16-18 years)	Age (16-18 years)
Median			
Energy (kcal)	1320	2011	1751
Iron	6.4	10.1	7.4
Zinc	3.8	8.7	7.3
"Younger" adolescents	Age (13-14 years)	Age (13-15 years)	Age (13-15 years)
Energy (kcal)	1275	1881	1455
iron	5.7	9.1	5.9
zinc	3.4	8.1	6.5

Although there was a lack of the remarkable actual changes in the intake of micronutrient in young children (Table 4); a tangible improvement of the intake has been observed in adolescent population. The Table 5 revealed the dietary intake surveys at the three time-points (NMS 2011-12[4], BIHS 2015[38] and INFS/FAO, 2017) comparing the intake of energy and two key micronutrients in Bangladesh context—iron and zinc in adolescent girls. The NMS 2011-12 is a nationally representative survey; the BIHS (2015) is a large survey in the rural context; and the INFS/FAO (2017) is a large survey consisting of rural, urban and urban slum settings (Nazma Shaheen et al, Personal communication). The NMS 2011-12 used a validated seven day semi-quantitative FFQ, the BIHS (2015) used a single 24-hour dietary recall; while the INFS/FAO (2017) used the food-weighing. The intake of iron was improved to some extent in the INFS/FAO (2017) study compared with the NMS 2011-12 (7.4 mg vs. 6.4 mg) in the older adolescent group. However, the intake of zinc marked major increase over these studies (7.3 mg vs. 3.8 mg). This is probably can be explained in lights of the substantial increase in the intake of animal source foods 30, 31 which is the major source of zinc. The increase was observed in the intake of energy between the studies. In the younger adolescent group, the similar pattern of increase in the intake of iron and zinc was observed. Accounting for usage of the different dietary assessment methods and a slight mismatch of the age groups, the increment of the intake in the INFS/FAO (2017) study from the national survey (NMS 2011-12) suggest a logical progress and consistent with the improved quality of the macro-level food intake reported in the other national surveys.

Nonetheless, the intermediate data point (BIHS 2015) showed a higher amount of the intakes compared to the NMS 2011-12 and the INFS/FAO (2017). This is hard to explain the slight unexpected deviations of intakes in the BIHS (2015). However, the probable reason could be the methodological difference in the measurement which used multiple Food Composition Tables and combined them to compile its own for the calculation.[38] Nevertheless, considering the

NMS 2011-12 and the INFS/FAO (2017), some improvement of the intake of the key micronutrients in the adolescent population is obvious and logical.

A recent cohorts study among the adolescent population of a northern district suggested improvement in the serum markers of micronutrients status relative to the 2011-12 national micronutrient survey estimates. But the study did not estimate the quantitative micronutrient intakes (JiVita /Johns Hopkins University Cohorts Study--Baker S. et al; personal communication, Table 6).

Table 6: A comparison of the selected micronutrient status of the NMS 2011-12 and the JiVitA/ Johns Hopkins University Cohorts Study (Personal Communication)

Micronutrient Deficiency (%)	NMS 2011-12[4] (Children aged 6-59 mo)	NMS 2011-12[4] (Non-pregnant women 15-49 y)	NMS 2011-12[4] (Children aged 6-14 y)	JiVitA/Johns Hopkins University Cohorts Study (2019) (Children aged 9-13 y)
Anemia	33.1	26.0	17.1-19.1	11.4
Iron deficiency	10.7	7.1	3.9-9.5	0.5
Zinc deficiency	44.6	57.3	-	23.8
Iodine deficiency	-	42.1	40.0	21.9
Folate deficiency	-	9.1	-	3.3
Vitamin B12 deficiency	-	22.0	-	5.2

3.2.2 Final selection of the reference micronutrient level (i.e. projection level)

Therefore, upon appraisal of these national surveys and studies, the nationally representative national micronutrient survey 2011-12[4] with its complete repertoire of serum and urinary nutrients level and the quantitative micronutrient intakes segregated by the animal and plant sources, comparability of nutrient intakes with some later studies; and a thorough multivariable analyses studying the association of the micronutrient intake and serum status, [36,39-41] offers the most suitable representation of the pre-COVID-19 reference micronutrient status (Table 7).

Table 7: Status of the selected micronutrient deficiencies considered as the reference data (NMS 2011-12) [4]

Micronutrient deficiency	% (95% CI)
Vitamin A deficiency	
Preschool age children (6-59 mo)	20.5% (15.9,25.0)
School age children (6-14 y)	20.8%(17.2,24.4)
Non-pregnant non-lactating women (15-49 y)	5.3%(2.8,7.8)
Iron deficiency	
Preschool age children (6-59 mo)	10.7%(5.8, 15.6)
School age children (6-11 y)	3.9%(1.7,6.1)
School age children (12-14 y)	9.5%(-0.6,19.7)
Non-pregnant non-lactating women (15-49 y)	7.1%(4.2,9.9)
Zinc deficiency	
Preschool age children (6-59 mo)	44.6%(34.3, 54.9)
Non-pregnant non-lactating women (15-49 y)	57.3%(51.1,63.4)
Vitamin B12 deficiency	
Non-pregnant non-lactating women (15-49 y)	22.1% (14,29.9)
Iodine deficiency	
School age children (6-14 y)	40.0% (29.3-50.6_
Non-pregnant non-lactating women (15-49 y)	42.1%(31.7-52.5)

3.3 Urban slums are most affected with micronutrient deficiency

Furthermore the NMS 2011-12 showed that the urban slums are most vulnerable to micronutrient deficiency. Vitamin A deficiency in preschooler, school age children and non-pregnant non-lactating women were 38.1%, 27.1% and 6.9% respectively. Zinc deficiency in the preschooler and non-pregnant women were 51.7% and 66.4% respectively. The deficiencies were much higher relative to national and other domains (Table 7).

Though the above review of literature did not return any studies on iodine intake/fortification, we referred to the recent Multiple Indicator Cluster Sampling Survey 2019,[32] published just prior to the pandemic for the data on salt iodization. Interestingly, as per the survey the prevalence of usage of the adequately iodized salt (>15 part-per-million) was 58.5%. The estimate was consistent with 57.6% reported in the national micronutrient survey 2011-12, [4] rationalizing the micronutrient survey as the pre-pandemic reference data for iodine alongside some other studies [32,42,43] conducted during the interval time to the onset of the pandemic.

3.4 General principle/concept for the projection

From the review of the dietary intake and micronutrient status over the preceding decade (2010-2020), some generalizations can be made in order for a gross projection of the micronutrient status in the aftermath of the pandemic.

Intake aspect

The preceding data illustrate that the quality of diet has improved (i.e. increase in the intakes of animal source foods and animal proteins) over the last several years. Though somewhat inconsistent over the population groups, but some increase in the intake of the key micronutrients (e.g. iron, zinc) has been observed, particularly in adolescent populations. Furthermore, in absence of an updated data separated by food sources of micronutrients (Animal vs. plant-sourced) it is unknown that to what extent the largely-dominant share of the plant based foods in the traditional intake pattern which is associated with a low bioavailability of micronutrients has moderated since the NMS 2011-12.[4]

Serum micronutrient aspect

The above review suggests that there is a dearth of recent data on serum micronutrients within a short interval (e.g. 1 year) before the onset of the pandemic. The only available data concerning that period is the JiVitA/Johns Hopkins University cohorts study in adolescents which in comparison to the NMS 2011-12 reported improvement of serum statuses of some micronutrients (zinc, iron, folate, vitamin B12, vitamin D) and a seeming improvement in the prevalence of anemia in a rural setting of Bangladesh (Table 6). Although the study lacked the data on the quantitative micronutrient intake, the other surveys estimated an increment of intake of the key micronutrients in adolescent populations compared to the NMS 2011-12 estimates (INFS, 2017). This complements with the increase in the general food production and consumption especially in poultry, fish, eggs, and vegetables over the last decade. Hence, the observed improvement in the serum micronutrient statuses even in a remote rural setting among the adolescent girls (JiVitA cohorts study) is consistent with a logical consequence.

Therefore, we posit that the decline of people's employments, earnings, price hike of food stuffs and heightened food insecurities and poverty in conjunction with the COVID-19 pandemic might have offset the gains in the improving quality of dietary intakes; and the possible improvement of the serum micronutrient status over the past decade and plausibly resulted in the serum micronutrient status regressed back to the 2011-12 level (i.e. reference level).

3.4.1 A simplified conceptual framework

Table 8: A brief conceptual framework underpinning the projected decline of the micronutrients

Reference level of projection [NMS 2011]
A comprehensive reference data is needed which is robust and nationally representative; so that a reasonable past-point is considered for the projected decline of the micronutrient status due to the pandemic[4]

Basis of the projection

Qualitative improvement of food intake [HIES 2010------HIES 2017]

↓

Improvement of animal source protein intake [NMS 2011/12-----INFS 2017]

↓

Improvement of micronutrient intake [NMS 2011/12-----INFS 2017]

↓

Improvement of micronutrient status [NMS 2011/12------JHU 2019]

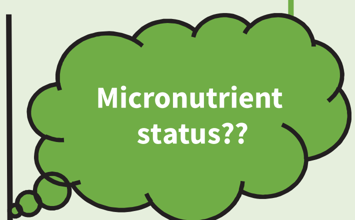
↓

The Reversal —the COVID 19 related adversaries on the socio-economic status

a. Income dropped [After the onset of the pandemic]
   Urban slums: 75%[8]
   Rural: 63% [8]
   Rural: 72% [10]

b. Price of foods has increased [April 2020- May 2021]
   Boro (coarse): 7.5%
   Pulse (khesari): 47.8%
   Broiler chicken: 30%

c. Escalating household food insecurity
   NMS 2011-12: 49%
   2020-21: 70% (rural) -90%(urban slum) [10, 11]



3.5 Micronutrients considered for the appraisal

Four of the most important micronutrients of public health importance in Bangladesh context Vitamin A, iron, zinc and iodine were considered for the appraisal. Vitamin B12 was included as its source is exclusively from animal foods, [44] which during the limited economic activities due to the pandemic has a strong propensity of having a decreased intake. Vitamin D was not considered for the risk-projection because of its different nature of sources; and it's recognition as a prohormone with possible different mode of biological metabolism and activities.[45] Calcium is not considered as the mineral is a macronutrient.

3.6 Specific technical elements considered for the appraisal of the risk projection of the selected micronutrients

3.6.1. The pre-COVID-19 deficiency status of the micronutrients, i.e. reference data (Table 7)

The estimates of the reference survey were used as the magnitude of the preexisting deficiencies and to assess the degree of the projected risk. A high magnitude of the pre-pandemic deficiency implies that there are prevalent issues underlying the condition, and these led the condition (i.e. micronutrient deficiency) to happen readily; and as such indicating a high vulnerability.

3.6.2 Amount of dietary intake of the micronutrients

The micronutrient intake data of the reference survey was used. The amount of the intake of the micronutrients was appraised relative to the estimated average intake (EAR) and/or recommended dietary allowance (RDA). The proportion of the population meeting the EAR and/or RDA and the amount of intake as the proportion of RDAs are plausibly the measures of vulnerability; and were used for the appraisal of the serum deficiencies.

3.6.3 Relative attribution of food sources of the intake of the index micronutrients

The reference data was used to appraise the relative contributions of the plant-sourced (low bioavailable) vs. animal-sourced (higher bioavailability) micronutrients. The magnitude of attribution of the plant-origin micronutrients which is low in bioavailability and/or bio-conversion relative to the total intake is a clue to vulnerability; and was used to assess the projected risk.

3.6.4 Reflection of the environmental/geological factors affecting the status of the micronutrients (e.g. groundwater iron)

The environmental geological factor is relevant for iron. Groundwater is the prime potable supply in the country and contains predominantly a high but variable amount of iron.[46, 47] Groundwater iron is positively associated with ferritin concentration in populations.[39, 48] It was considered in assessing the projected risk of the decline in the iron status. Environmental factors also influence iodine as the country is plain and riverine with significant washout effects of iodine in the soil.[49]

3.6.5 Consideration of fortification/supplementation programs and the program coverage

National mandatory edible oil fortification program of Vitamin A was appraised to complement the probable risk-grading of Vitamin A deficiency. To evaluate the risk of the decline of the iodine nutriture, salt iodization program was reviewed during the pandemic and the pre-pandemic times. Magnitude of the coverage of the programs was used for the risk-appraisal.

3.6.6 The determinants affecting the serum micronutrients in Bangladesh context (analyses from the national micronutrient survey 2011-12)

The present evaluation considered the multivariable regression analyses which identified the key determinants of serum micronutrient level at the nationally representative scale, derived from analyzing the national micronutrient survey 2011-12, i.e. the reference data.[39-41] The analysis divulged some key determinants—e.g. low socio-economic status (SES), food insecurity and low income were commonly associated with lower status of the nutrients. Intake of animal-origin and plant-origin micronutrients was associated with higher and lower serum status of the micronutrients respectively.

The Figure 5 depicts—a. the derangements in people's food security and food intake as the consequence of the pandemic, b. the reference data for the micronutrient projection; and c. the technical and programmatic elements that aided in the projection.

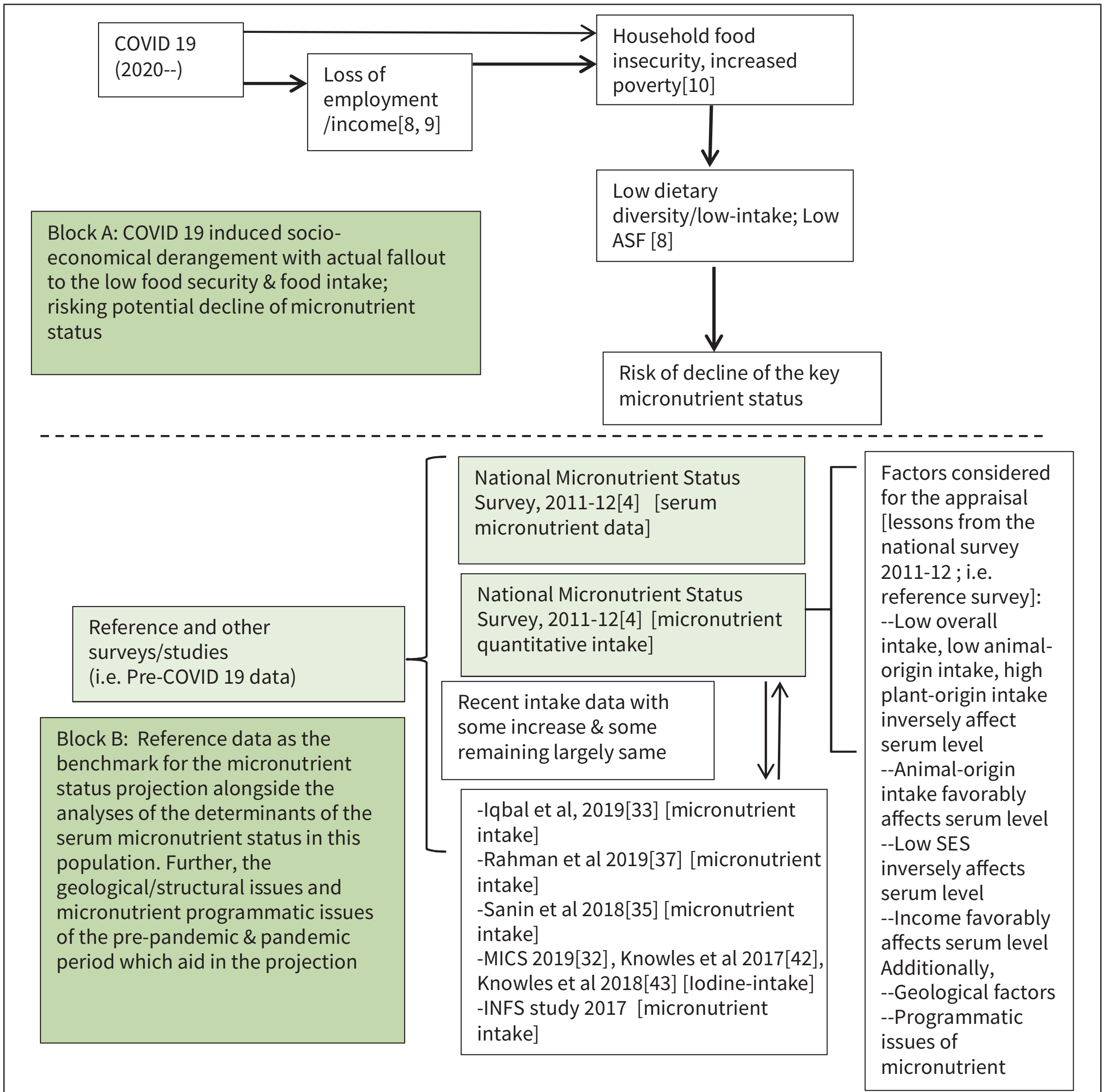


Figure 5: Overall conceptual assessment of the risk of the decline of micronutrient status in the context of Bangladesh due to the COVID 19 pandemic

Finally, after the appraisal over the considered factors, a provisional categorization of potential risk of the decline of the micronutrients was done. The basis for assigning the risk-categories of the decline of the micronutrient status is an operational allocation of scores against the appraisal parameters. For zinc, Vitamin A, iron and vitamin B12 the appraisal parameters are—1. The preexisting deficiency, 2. Proportion of population failing to meet the EAR, 3. Contribution of plant origin micronutrients to the total intake, 4. Geological influence, 5. Programmatic aspects including the coverage of the programs (in relevant micronutrients) and 6. The COVID 19 induced disruption of the pathway linking the serum micronutrient status.

It is worth to note that the preexisting deficiency, intake profile and relative sources are based on the pre-pandemic general status of the indicators (i.e. derived from the reference data) and used to define the relative magnitudes of risk depending on some preset standard and/or operational cut-offs. Geological features are structural and determine risk or protection independent of the pandemic induced adversaries. Programmatic issues have been existing before the pandemic ensued and its presence or absence determines the risk. Coverage of the programs is pre-pandemic as well as some decline might have occurred due to the pandemic. Low coverage implies the higher risk and the vice versa. Finally, the COVID-19 induced disruption of the factors affecting micronutrient status is the result of direct effect of the pandemic on people; as such it is a proximal determinant of the risk.

3.7 Principle and protocol of scoring for the risk-appraisal for the projection

3.7.1 Vitamin A, iron, zinc and vitamin B12 (Table 13)

The basic parameters considered for this appraisal are assessed objectively. The basis for the categorization of the projected risks sits on the most commonly applied dietary intake standards---e.g. the estimated average requirement (EAR) –the intake that is consistent with adequacy for 50% of population (FAO/WHO 2004). The appraisal was done as to what proportion of the population has fallen short of this intake. In the case of less than 50% of the population failed to meet the EAR, this underscores the "favorable" intake and allocated with a low risk score (e.g. 1). Conversely, higher than the 50% population failing to meet the EAR constitutes an "unfavorable" intake and being allocated with higher risk score (e.g. 2).

The appraisal estimated the relative proportion of the plant source micronutrients to the total intake. By and large in the developing countries roughly two-thirds of the micronutrient intake comes from plant based sources (i.e. predominantly cereals and legumes) and the rest from the animal sources.[50] Hence, the intake of the plant based micronutrients lesser than the above standard is indicative of "favorable" intake and assigned a low score of risk (e.g. 1). While the larger than that two-thirds cut-off point (65%) is consistent with the worse (i.e. in terms of poorer bioavailability of the plant based micronutrient) and gets a higher risk score (e.g. 2). However, there is an exception for vitamin B12 for which a different scoring is considered. Since the contribution of the plant source B12 is non-existent (i.e. 0%), the scoring system referred above is not applicable for vitamin B12. As the pandemic is likely to stress on the consumption of the ASF which is the sole source of vitamin B12, a score of high risk (e.g. 2) is applied straightway suggesting an increased "unfavorable" state.

However, there are the challenges to put all the four nutrients in a single format when the parameter of the preexisting prevalence (which is suggestive of the vulnerability of the deficiency status) is appraised. This is because of the inconsistency of the prevalence estimates of the different micronutrients that constitutes a public health concern. There is the lack of an unique number (i.e. estimate of proportion) which would define the burden of various micronutrient deficiencies at the level considered as "public health concern". Hence, we have taken into consideration the spread of different estimates of the deficiencies of the key micronutrients in Bangladesh -which typically ranges from 7-10% (iron deficiency) to 65% (zinc deficiency in slums). Therefore, the preexisting prevalence of deficiencies are covered over the quartiles and scored. As for example, a 30% prevalence of deficiency of a micronutrient falls into the 2nd quartile and gets a score of 2.

In regard to the geological influence which applies for iron among these four micronutrients, a slight modification is done in scoring. This is because, the relative influence of groundwater iron in maintaining good iron status at population level is far more influential than the dietary iron. Hence it is scored negatively (e.g. -1) in order to depict the heightened protective role.

Presence of multiple programs or a large scale/countrywide program indicates a "favorable" condition and scored at minimum consistent with low risk (e.g. 0). Absence of a program, single or low–scale programs are scored higher (e.g. 1) suggesting "unfavorable" condition. It is to be noted that "a" and "b" in the programmatic appraisal (Table 12) are used between them interchangeably (i.e. if one option is used, the other cannot be used).The presence of the undesirable programmatic issues imply—documented lapses in the program standards (e.g. fortification, supplementation), undesirable coverage of the program products/services, any unintended outcome of the programs with potential deleterious effects.

Program coverage was considered with particular emphasis on large/nationwide programs. Such as fortification of edible oil (Vitamin A), Vitamin A capsule supplementation for the children 6-59 months, salt iodization programs and iron-folic acid programs for the pregnant women. The scoring was based on the coverage estimates falling on the particular quartiles. As for example, <25% coverage is an "unfavorable" situation and scored high (e.g. 4) as a risk. There is no large-scale zinc nutritional program scaled up nationwide. There are sporadic programs of zinc fortified rice on a limited scale (under SSN programs). There is no dedicated program for promoting the intake of vitamin B12. Iron supplementation program for the children, such as the MNP programs are currently present sporadically. Hence, no scoring on the coverage is allocated on these programs, and their scale of appraisal is different with regard to the scoring range. For the presence of multiple large scale programs for a particular population group, the average of the coverage scores is considered for the risk appraisal.

The COVID 19 induced disruption of the pathway linking the serum micronutrient status, underscores the income/intake related adversaries due to the pandemic affecting negatively a favorable link to good micronutrient status. For example, people who used to buy the packet salt are compelled to buy "open" salt which is cheaper and poor in iodine content in the aftermath of the pandemic.

3.7.2 Iodine (Table 14)

For iodine the parameters of consideration are slightly different. These are—1. Preexisting status/deficiency, 2. Use of adequately iodized salt (>15 ppm), 3. Use of "open" salt, 4. Geological influence, 5. Programmatic aspects and 6. The COVID 19 induced disruption of the pathway linking the urinary iodine status. Appraisal of the preexisting iodine status for the risk projection is not straightforward as the concept of subclinical iodine status/deficiency itself may be confusing. It is inappropriate to state that if the urinary iodine level (UIC) in a proportion of a population (e.g . X%) falls below a cut-off (100 µg/L), then the prevalence of the iodine deficiency will be X%. The appropriate interpretation is if the median UIC is <100 µg/L, the entire population is iodine deficient and the vice versa. For the present appraisal considerations are given on--- 1. State of subclinical iodine status expressed as median urinary iodine concentration (UIC) relative to the cut-off (100 µg/L). From the current subclinical iodine data[26] two aspects are considered—at the national level 100% population could be non-deficient/iodine-sufficient (median UIC>100 µg/L) and a quartile (as a whole) or a multiple of the quartiles of the population sorted by the wealth status (i.e. wealth index) might be iodine deficient (median UIC<100 µg/L). This is because in Bangladesh, though population at the national level are iodine sufficient (median UIC >=100 µg/L); when the population is decomposed by SES to derive the wealth-quartiles, it has been observed that one or more bottom (i.e. poorest) quartiles were iodine deficient (median UIC<100 µg/L). Therefore, the risk-categories are devised as the whole (100%) population is iodine sufficient being allocated a low risk score (e.g. 1). If one quartile (25% of the population) sorted by the wealth index is iodine deficient, it gets a higher risk score (e.g. 2); and so on. In concurrent presence of the iodine sufficient status as a whole at the population/national level and iodine deficient state in one or more quartiles based on the wealth status, the quartile based (SES) deficiency has been taken into consideration and its pertinent risk-score is applied.

Consideration is given on the usage of the adequately iodized salt (>15 ppm) at household level. An estimate of 90% is the WHO recommended and also it is the target of the Bangladesh NPAN2. So, the operational classification of the risk-scores are equal range of proportions--- 90-81%=1, 80-71%=2, 70-61%=3 and 60-50%=4. Usage of the open salt which is poor in iodine content is considered. The benchmark was considered from the NMS 2011-12 when 25% of the salt samples at households were reported to be the "open" salt at the national level. So the estimates less than<25% gets risk-score of 1 indicating "favorable" status and >=25% is scored 2 consistent with the worse situation. In regard to the geological influence on iodine status, since Bangladesh is a flat riverine plain land, the iodine in soil mostly leaches out. Hence, the geological influence affects the iodine deficiency positively and gets a higher risk- score (e.g. 1).

Regarding the program coverage (i.e. salt iodization) the scoring was based on the coverage estimates falling on the particular quartiles. As for example, <25% coverage is an "unfavorable" situation and scored high (e.g. 4) as a risk. Scoring principles for the programmatic appraisal and the pandemic induced disruption on the positive or negative determinants of iodine status are similar to as described in relation to Vitamin A, iron, zinc and vitamin B12.

4. Appraisal of the selected micronutrients

4.1 Zinc

Bangladesh has a high burden of the pre-COVID-19 zinc deficiency—44.6% in preschool age children and 57.3% in women [4] (Table 7). The proportion of the 2-3 year-old and 4-5 year-old children not meeting the EAR is 93.4% and 88.1% respectively.[4] The proportion of the children aged 2-5 years meeting the dietary RDA is 11.4-44.7% (Table 9) and the proportion of non-pregnant non-lactating women meeting RDA is 0.5-6.4%.[4, 41] Two-thirds (65%) of this insufficient intake comes from plant sources rendering them poorly bioavailable. Patterns of this intake remained largely unchanged as suggested by the recent studies.[33, 35, 37] There is a zinc supplementation program as part of the diarrhea treatment- but it is a medicinal intervention and not a public health nutritional measure. There is the provision of providing zinc fortified rice to help the underprivileged families under the government's social safety net programs, but the coverage is suboptimum. Positive determinants of serum zinc status in Bangladeshi populations are—animal sourced zinc, spending capacity of households and the higher socio-economic status. The intake of plant sourced zinc affects the serum zinc concentration adversely.[41] Hence, with the impact of COVID-19 with a potential compromization of the access to zinc rich food (e.g. animal source foods) and reduced food security and dietary diversity in the low SES populations, the plight of zinc status looks bleak (Figure 7).

Table 9: Serum and dietary evaluation of zinc

Evaluation of zinc					
	Preexisting prevalence	% of population did not meet EAR	% plant based zinc to total intake	Positive determinants	Negative determinants
Preschooler	44.6%	93.4% (2-3 y) 88.1% (4-5 y)	52%(2-3 y) 65%(4-5 y)	-Animal-source Zn -High SES -High Spending ability	Plant source zinc
NPNLW	57.3%	77.2% (18-49 y)	65%		

4.2 Iron

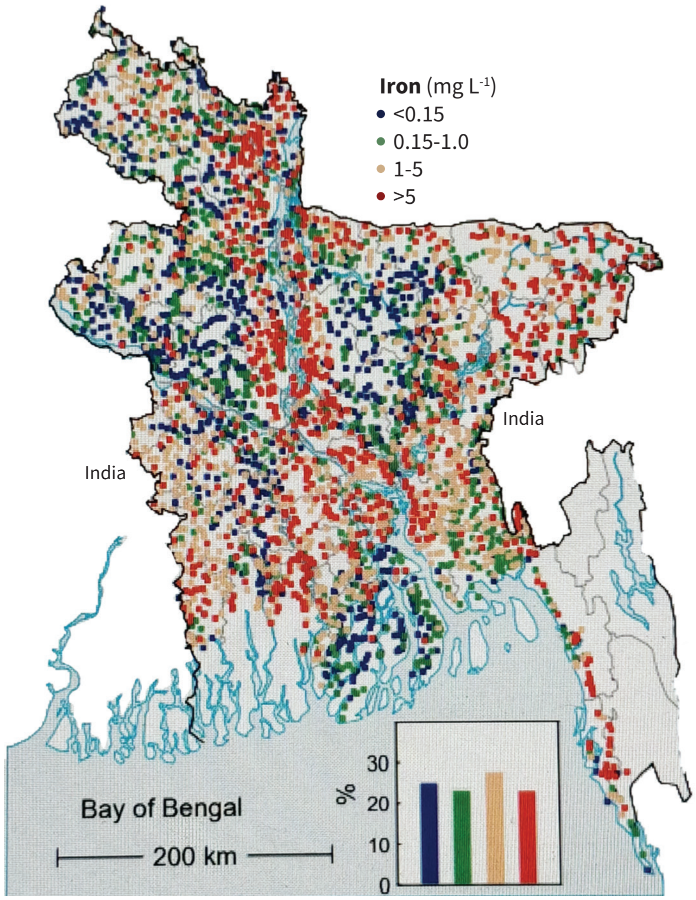
Iron depicts an interesting scenario. Similar to zinc, the dietary intake of iron in the populations is grossly inadequate. Mean intake of dietary iron in children 2-5 years old is 4.59 mg/day [26] falling fairly short of the RDAs as per the age subgroups (7-10 mg/day). 51 The relative intake in women is further lower. A paltry 2.8-5.8% (Table 10) of the children met the RDA [4] for iron and proportionately a small amount (7-14% of RDA) comes from animal sources in a cereal based dietary system with a poor bioavailability. The contribution of plant origin iron to the total intake was 68.9% (2-3 year old children), 77.6% (4-5 year old children) and 85.6% (19-49 year old women). The proportion of the 2-3 year-old and 4-5 year-old children not meeting the EAR is 42.6% and 52.3% respectively.[4] The proportion of the non-pregnant non-lactating women not meeting the EAR is 65.4%. The intake remained largely unmoved as suggested by some recent studies.[33, 35, 37] None of the women meet the RDA for iron. Interestingly, unlike the zinc status, the national prevalence of iron deficiency is low—7.1-10.7% in the preschool children and non-pregnant women (Table 7). Furthermore, in a recent large birth-cohort study the prevalence of ID in 9-13 years old children was 0.5% (Personal communication).

Table 10: Serum and dietary evaluation of iron

Evaluation of iron					
	Preexisting prevalence (%)	**% of population did not meet EAR**	**% plant based iron to total intake**	**Positive determinants**	**Negative determinants**
Preschooler	10.7	42.6% (2-3 y) 52.3%(4-5 y)	68.9%(2-3 y) 77.6%(4-5 y)	-High GW iron area -HH food insecurity	Urban area
NPNLW	7.1	65.4% (19-49 y)	85.6% (19-49 y)		

4.2.1 Groundwater iron vs. iron deficiency

The reason for this low prevalence of ID despite consuming overtly sub optimum dietary iron is the iron obtained from groundwater, the predominant drinking source of the population.[39, 48, 37, 52] This iron from drinking water maintains a satisfactory infection-adjusted serum ferritin well above (~3-4 times) the cut-off point defining iron deficiency.[4] The influence of dietary iron on serum ferritin status is insignificant compared to that of high groundwater iron. This is evident from a recent trial of testing the efficacy of a low dose iron-containing supplements on ferritin status in Bangladeshi children exposed to high groundwater iron[37] and a study which illustrated the effect of groundwater iron on iron status in Bangladeshi women.[48] This owes to the fact that when the body reserve of iron is sufficient, absorption of exogenous iron (supplementary or dietary) is inhibited, as the hepcidin - mediated negative feedback regulation is activated. [53] In the Rahman et al study[37], in a high groundwater iron setting, despite consuming just 800 ml water in a day, the intake of groundwater iron in children 2-5 years was 4.8 mg/day which was about 50% higher than the iron taken from the traditional diet (3.13 mg/day). In the Merrill et al study[48], the adult women who consumed ~2.5 L of water in a day, the intake of iron through the water was nearly 45 mg/day which was almost equal to the upper level of the intake of iron from water and the supplements, and the intake above which the undesirable health effects may happen. To complement this high intake of iron from water, the bioavailability of the water iron is much higher than the traditional Bangladeshi diet; 25-40% [54] for groundwater iron vs. 5% for the traditional diet. For this reason, it was observed that, even in the children who drink from the tube wells with considerably low level of iron (i.e. <0.8 mg/L) have the median hemoglobin at the non-anemic level and comparable to the hemoglobin level of the children whose potable water is groundwater with a high level of iron (>=2 mg/L) (Rahman, personal communication). The map depicted below (Figure 6) provides a glimpse of the distribution of iron in groundwater in Bangladesh.



Groundwater Studies of Arsenic Contamination in Bangadesh
DPHE/BGS/DFIF (2000)

Figure 6: Distribution of iron in the Bangladesh groundwater
Source: Department of Public Health Engineering & British Geological Survey, 2001 [46]

The above map depicting the distribution of iron in Bangladesh groundwater clearly states that most of the areas have a fair concentration of water iron with a negligible proportion of the wells with the “zero” concentration of iron. Taking in consideration the research findings, very low prevalence of ID in the large section of Bangladeshi population and the protective role of the groundwater iron against the deficiency is comprehensible.

The relationship of the groundwater iron and it’s positive association with population level iron status in the Bangladesh population is a phenomenon first discovered in Bangladesh.39,48 However, the similar research have been initiated in the other neighborhood countries. In Cambodia, the low prevalence of the population level iron deficiency was reported to be associated with the high level of iron in the drinking groundwater.55 Similar observation has been noted in Vietnam where iron content in groundwater is predominantly high 56. Hence, this phenomenon has started to get momentum in the other countries.

Predominantly high groundwater iron areas are the positive determinant of the serum ferritin status. Interestingly, household food insecurity, especially in rural settings of Bangladesh positively determines the higher ferritin status. Because, the households may be food insecure, but the source of the drinking groundwater is rich in wholesome iron contributing to the body iron status .[39]

Taking into consideration the above observations, it is apparent that the probable dietary limitation resulting from COVID-19 would unlikely to unfavorably impact the serum iron status in the overall populations-- because it's effect is negligible compared to the dominant effect of the water iron. However, in the large cities of the country, a sizable underprivileged population reside, who are one of the worst affected by the loss of income and employment. The potable water supply in the large cities is chemically treated and as such contains a very low level of iron if any. Hence, these populations are not protected by the water iron and would be prone to have decreased iron status due to the pandemic context. There are the regions in Bangladesh –i.e. the Barind-Tract areas and the adjoining areas with the largest inland water body of the country (i.e. Chalan beal) where the iron content in groundwater is consistently low. [46] Such districts are-- Pabna, Natore, Rajshahi and Chapainawabganj. The population of these areas is less likely to have a satisfactory level of body iron reserve from the drinking groundwater iron. Therefore, the pandemic-induced adversaries on the financial and food wellbeing would put them on the high risk iron deficiency. Additionally, in the southern coastal areas in order to avoid salinity in water, the wells are sunk at the great depth (in excess of 900 feet).[46] The concentration of iron in groundwater at such depth is negligible. Hence the population is not protected from the groundwater sources of iron. The pandemic-induced food insecurity and the limited intake might aggravate the iron status in this population. The overall pattern of the risk for the iron status is given in the figure 8. Pregnant women require additional amount of iron. The coverage of the iron-folic acid (IFA) program is suboptimum at 46%; [27] which was further affected adversely during the surge of the pandemic. Hence, the risk of decline of iron status might be higher in pregnant women.

4.3 Vitamin A

The pre-COVID-19 prevalence of subclinical Vitamin A deficiency (serum retinol<0.7 µmol/L in children and <1.05 µmol/L in women); [57] was 20.5%, 20.8% and 5.3% in preschool children, school age children and non-pregnant non-lactating women of the reproductive age respectively (Table 7). The magnitude of the deficiency is particularly high in children of both age groups which were further higher in the slums population (38%).[4] Accompanying the infection-adjusted high retinol deficiency, the dietary intakes of Vitamin A was sub optimum across the population groups. The proportion of the children (2-5 year-old) and non-pregnant non-lactating women not meeting the EAR is 47.8% and 41% respectively.[4] Only around onethirds of the preschool age children and women met the RDA for Vitamin A. Intake of higher bio-convertible animal source Vitamin A constituted a meager 4-10% of the RDA in the populations (Table 11). Of the total intake, a very high proportion (children: 70-75% and women: 83%) was consumed from one single source—leafy vegetables with a low bio-conversion efficiency.[40] Intake of animal sourced food was a strong predictor of the total and animal-sourced Vitamin A.[40] Intake of leafy vegetables, residing in the slum area and taking Vitamin A supplements more than 1 year back are the negative determinants of serum Vitamin A status.

Table 11: Serum and dietary evaluation of Vitamin A

	Preexisting prevalence	% of population did not meet EAR	% plant based Vitamin A to total intake	Positive determinants	Negative determinants
Preschooler/ School age children	20.5-20.8%; 38% (Slums)	47.8% (2-5 y)	52.6%	-Intake of animal source food	- Intake of leafy vegetables - Slum area -VAS >12 months (pre-school)
NPNLW	5.3%	41% (19-49 y)	86%	-Urban area	

With the consumption of largely plant based Vitamin A, the population level status has essentially remained stagnant over the decades (between 1997 & 2011), suggesting a weak potential of the traditional diet to elevate the retinol status.[40] However, with COVID-19, the worsening of the food security and animal-source food availability, especially in the underprivileged population some drop of Vitamin A status from the dietary perspective is not improbable.

Fortification of edible oil with Vitamin A mandated by the Bangladesh universal fortification of edible oil with Vitamin A law has been enacted since 2015[58]; nonetheless the piloting of the fortification of oil had started following the NMS, 2011-12. Vitamin A fortificant—retinyl palmitate provides the preformed highly bioavailable Vitamin A, therefore, a program functioning over that duration should have plausibly elevated the Vitamin A status of the population. However, the programming and enforcement constraints and issues have been documented. Over this period no nationally representative data is available to assess any progress of the subclinical VAD. A recent market assessment of edible oil (2017) has shown that only 41% of bulk oil (non-bottled) was fortified with Vitamin A.[59] A report on the performance of Bangladesh's oil fortification activities stated that, of the "bottled" oil (with a 35% market share) just 69% of the samples met the optimum standard of fortification, while the "bulk/non-bottled" variety (with a 65% market share) had a scanty 7% of the samples meeting the standard.[60] Given that an estimated two-thirds of the population in Bangladesh uses non-bottled oil, this means potentially, there is low population coverage of fortified edible oil. The non-bottled oil is substantially cheaper (BDT 15-20 less per liter) than the bottled oil[60] - a fact that will push additional people to purchase the non-bottled oil due to the pandemic induced income loss. In regard to the coverage of the fortified oil, fortification at any level (above standard, within standard and below standard) is 60.6% (Global fortification data exchange, GAIN 2021). Higher estimate implies lower risk of the decline of the Vitamin A status in population. The country has a vibrant Vitamin A supplementation program for the under-five children operational over the decades. However, its impact in elevating the serum retinol status has been observed to be limited.[40] The coverage of the supplementation program in children is 79.1% (BDHS 2017). The above information summed up, points to a mixed outlook of serum retinol status. On one hand, a supposedly effective fortification program has been running for 7-8 years and might promote the Vitamin A status. Conversely, the possible worsening of the dietary intake due to the pandemic context and some unfavorable programmatic issues of the fortification might compromise the due coverage and effectiveness of the program. As per the EPI coverage evaluation survey 2019 report —overall, the coverage of Vitamin A supplementation in young children is satisfactory with 89-95%.[61] Furthermore, the survey indicates that there is some lagging in some of the districts. Although, the effect of Vitamin A supplementation in children on the improvement of Vitamin A status in Bangladeshi setting is limited, this probably adds to the risk to the decline of the Vitamin A status in some of the districts in the pandemic context. This has been reflected in the projected risk-mapping for Vitamin A (Figure 8).

4.4 Iodine

Iodine is a key micronutrient in the context of Bangladesh. Due to the predominant flat riverine and flood plains of the country and the leach out effect of iodine off the soil due to heavy and torrential rain, the traditional diet has a limited contribution in iodine nutriture. It hugely imparts to the universal salt iodization program. Hence, our appraisal of iodine draws on the preexisting iodine status in population, the salt iodization programmatic issues as well as the financial limitation of the poor population induced by the pandemic--to determine the post-COVID-19 outlook of the nutrient.

The pre-pandemic status of the population level subclinical iodine was consistent with a public health concern. In the school age children, 33.8%[62] & 40%[4] and in women 38.6%[62] & 42.1%[4] had urinary iodine concentration (UIC) <100 µg/L. Though at the national level median UIC was above 100 µg/L, when the population is decomposed by wealth quintiles, up to 50% (poorest two quintiles) of the population had the median UIC<100 µg/L which is consistent with subclinical deficiency.[4] To complement the iodine status the national usage of adequately iodized salt (>15 ppm) was suboptimum—57.6%,[4] 50.5%[42] and 58.5%.[32] The household usage of the adequately iodized salt was modest at 35% in the poorest SES.[32] Usage of the open/loose salt at the rural areas was ~25% which increased to 37% among the poorest households (Table 12).[4] Conducted in 2015, Knowles et al from a nationally representative survey have reported that the packaged salt contained 3.8 times more iodine than the open salt.[43] The coverage of the fortified salt relative to the total population is 69%.[63] The lower is the estimate the higher is the risk of decline of the sub clinical iodine status in population.

Table 12: Subclinical status and the programmatic evaluation of iodine

Evaluation of Iodine							
	Preexisting status		**Population using adequately iodized salt (>15 PPM)**	**Adequately iodized salt in the poorest SES**	**Use of open salt**	**Positive determi-nants**	**Negative determi-nants**
	UIC <100 µg/L	**% Deficient1**					
School age children	33.8%, 40.0%	25% [lowest quintile]	57.6%, 50.5%, 58.5%	35%	25% [Rural] 37% [Poorest]	-Urban area	-HH food insecurity & poverty -High cost of packet salt -Use of industrial salt
NPNLW	38.6%, 42.1%	50% [lowest two quintiles]					

[1]Population disaggregated by wealth-quintiles (lowest) with median UIC<100 µg./L (at the quintile level)

Household food insecurity, poverty, high cost of packet salt and the usage of the industrial salt negatively affect the subclinical iodine status. On this background of the sub optimum status of the population iodine nutriture, some favorable programmatic issues have ensued as the pandemic heralded. The Government of Bangladesh has issued the directive for smooth distribution across the country of a number of essential goods. Being an essential commodity nationwide distribution of salt was uninterrupted.[64] The procurement of the premix (KIO3) was optimum and unaffected by the pandemic.[65] This is evident from the trend of the salt production and premix procurement in the first 6 months of 2020 (lockdown time included) which was consistent over the same months of the preceding year (2019) (Figure 7).

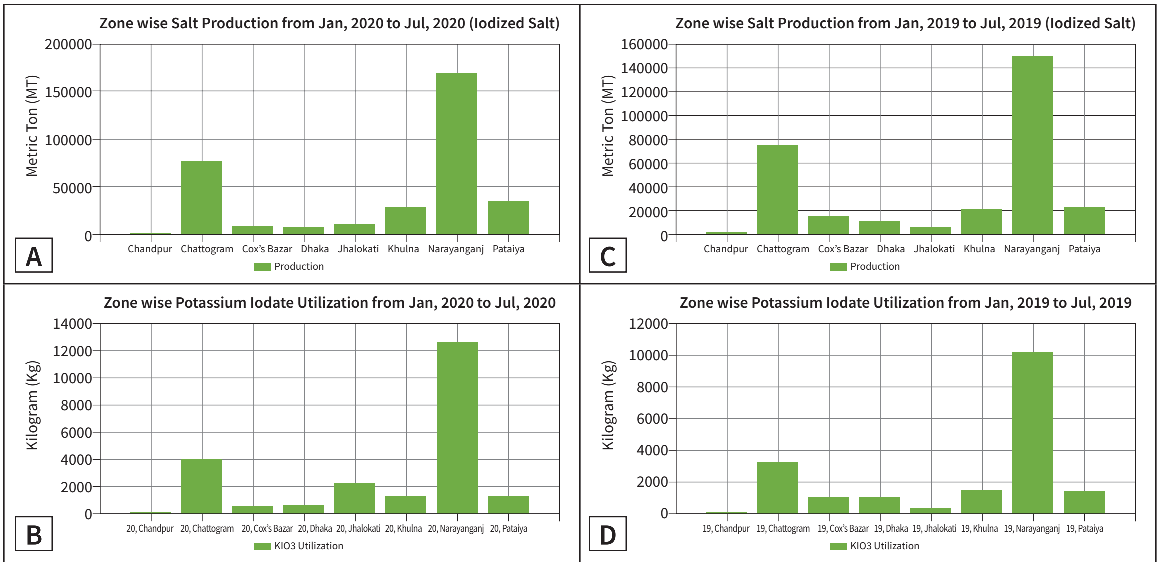


Figure 7: Comparative pattern of the zonal production of salt (block# A, B) and the procurement of KIO3 (block# C & D) of the pandemic year (Jan-Jul 2020) vis-à-vis the similar period of the preceding year (2019). The pattern of the salt production and the procurement of the premix are consistent over the years.

Courtesy: The CIDD project, Ministry of Commerce, GoB (permission obtained)

The price of the package (i.e. branded) salt has remained unchanged over the pandemic time.[66] However, the price of the coarse salt (produced by small millers) is considerably cheaper; about one-half or less that of the package salt.[67] There are several issues with this type of salt (coarse salt);---a. Due to the reluctance in the use of the Salt Iodization Plant (SIP) and technological limitations of the iodization process with the small millers and the packing issues, the iodine content can be uneven and inadequate. Secondly, the industrial salt often ends up being sold as open edible salt at the retailers and with the predicament of its packing issues may contain no or inadequate iodine.[67]

The 2015 survey observed that the households more vulnerable to poverty were twice as likely to purchase salt that is non-packaged (or open/loose) which is more likely to be salt that is not adequately fortified or without iodine fortified industrial salt.[43] Henceforth, during this pandemic the disadvantaged people hard-hit by the financial crunches are more likely to purchase the "cheap" salt, with the potential for further spiraling of iodine nutriture. Nonetheless, on the positive note, a revision of the salt law has enacted recently. The revised law will look into some key issues to address--such as more clarity in packaging, narrower range of iodization at the plant level (45-50 ppm), and stricter punitive measures for the breeches.[67] The law has the potential for promoting the usage of the adequately iodized salt.

Even so, taking in the consideration of the high magnitude of the pre-existing subclinical deficiency, continued high proportion of usage of the inadequately iodized salt, possible preference of the increasing number of the income handicapped (pandemic- induced) poor people for the cheaper sub optimally iodized salt, the immediate fallout of the iodine nutrition looks unfavorable, pending the optimum implementation of the revised salt law. As per the MICS 2019, the iodine content of the household salt was measured by the rapid testing. A considerable proportion of the samples were observed with no iodine (i.e. 0 PPM). At the Divisional level an arbitrary cut-off of 20% was considered for the occurrence of such iodine less salt, above which would pose an additional risk. The Divisions-- Rangpur, Rajshahi, Khulna, Mymensingh and Barishal exceeded the arbitrary limit and pitted for the incremental risk of the decline of iodine status due to the pandemic (Fig 8).

4.5 Vitamin B12

The serum data in women depicts the pre-COVID-19 deficiency of vitamin B12 is high at about 22%,[4] (Table 7). The vitamin comes exclusively from animal foods which are consumed at low level. The proportion of the non-pregnant non-lactating women failing to meet the EAR is 71.7%. With the advent of the COVID-19 and the loss of employment, income, high food price, and food insecurity—the underprivileged populations are likely to consume much less animal foods, thus the prospect of deterioration of the vitamin B12 status seems high (Fig 8).

4.6.1 Allocation of scores on the parameters of appraisal (Zinc, iron, Vitamin A, vitamin B12)

Table 13: Allocation of scores on the parameters of appraisal (Zinc, iron, Vitamin A, vitamin B12)

Parameters of appraisal	Score allocation
1.Preexisting deficiency (%)[a]	a.<25%=1, b. 25-50%=2, c. 51-75%=3, d. >75%=4
2.(%) population did not meet the average required intake (EAR)[b]	a.<50%=1, b. >=50%=2
3.Proportion of plant based MN to the total intake[c, e]	a.<65%=1, b>=65%=2
4.Geological influence (if relevant)	a.Influences positively the serum status=-1 (Fe)[d] b.Influences negatively or no documented influence on serum status=1
5.Programmatic aspects	a. Presence of multiple /nationwide programs=0 b. No programs/single program/low-scale program=1 c. Presence of undesirable programmatic issues=1 d. COVID 19 influenced potential use of non-fortified/ low quality products=1 e. Absence of the issues (c & d)=0
6.Program coverage[f, g] data	
- Oil fortification with Vitamin A	a. <25%=4, b. 25-50%=3, c. 51-75%=2, d. >75%=1
- Vitamin A supplementation	
- IFA supplementation for pregnant women	
7.COVID 19 induced disruption of the pathway linking the serum micronutrient status	a. Positive link to serum micronutrient status negatively influenced by the COVID 19 related adversaries and/or the negative link to serum micronutrient status positively influenced by the COVID 19 related adversaries=1, b. Absence of the above=0

[a]Since the magnitude of deficiency of different micronutrients in Bangladesh is spread widely—four equal quarter segments are proposed. From lower to the higher quarters indicates higher existing prevalence and assigned with higher risk grade.

[b]Less than 50% of the population failing to meet the EAR constitutes a favorable intake and graded a lower risk grade.

[c]In the developing countries by and large the relative contribution of plant to animal sourced key micronutrients (Vitamin A, zinc, iron) are roughly two portions to one. Contribution of the plant source micronutrients less than that margin speaks about a good intake status and allocated a lower risk grade.

[d]The relative influence of groundwater iron in maintaining good iron status is far more influential than the dietary iron. Hence it is scored negatively in order to depict heightened protective role.

[e]In regards to the proportion of the population not meeting the EAR, for vitamin B12 a different scoring is considered. Since the contribution of the plant source B12 is non-existent, the scoring system is not applicable for vitamin B12. As the pandemic is likely to stress on the consumption of the ASF which is the sole source of vitamin B12, a risk score of high risk scoring (e.g. 2) is applied straightway suggesting an increased “unfavorable” state.

[f]There is no large scale public health nutritional program for zinc. There is no dedicated program on vitamin B12. Currently, there is no large scale iron supplementation program (such as MNP) for the children. Hence the program coverage scoring is not considered for these micronutrients.

[g]For multiple large scale/nationwide programs, the average of the coverage scores will be calculated and applied.

Score & risk-grade

Zinc (all), B12 (all), Iron (children, NPNLW, coastal belt, Barind-Tract etc) Total score=4+2+2+1+1+1+1+1=13 Low: ≤6; Moderate: >6-8; High: ≥ 8	**Vitamin A (all), Iron (pregnant women)** Total score=4+2+2+1+1+1+1+1+4=17 Low risk: ≤ 8; Moderate risk: >8-12; High risk: ≥ 12

4.6.2 Allocation of scores on the parameters of appraisal (Iodine)

Table 14: Allocation of scores on the parameters of appraisal (Iodine)

Parameters of appraisal	Score allocation
1. Preexisting sufficiency/deficiency (%)	a[a, e]. 100% sufficient=1; b[b]. <25% deficient=2; c[b]. 25-50% deficient=3, d[b]. >50% deficient=4
2.Use of adequately iodized salt (>15 ppm)[c]	a.90-81%=1, b.80-71%=2, c. 70-61%=3, d. 60-50%=4
3.Use of open salt (%)[d]	a.<25%=1, b. ≥25%=2
4.Geological influence (if relevant)	a.No influence on iodine status=0 b.Influences iodine deficiency positively =1
5.Programmatic aspects	a. Presence of multiple nationwide programs=0 b. No programs/single program/low-scale program=1 c. Presence of undesirable programmatic issues=1 d. COVID 19 influenced potential use of non-fortified/ low quality products=1 e. Absence of the issues (c & d)=0
6.Program coverage: salt iodization	a.<25%=4,b. 25-50%=3, c. 51-75%=2, d. >75%=1
7.COVID 19 induced disruption of the pathway linking the iodine status	a. Positive link to urinary iodine status negatively influenced by the COVID 19 related adversaries and/ or the negative link to urinary iodine status positively influenced by the COVID 19 related adversaries=1 b. Absence of the above=0

[a]Median UIC≥100µg/L for the entire population level.

[b]Deficiency (%) (median UIC <100 µg/L) disaggregated by socio-economic classes (i.e. SES quartile-based deficiency).

[c]The basis of the grading is the 90% target of adequate iodized salt (>15 ppm) is the NPAN2/WHA target. Our current estimate is between 50-60% margins. Hence, the subsequent 10 point margins up to the 90% constitute the remaining grades.

[d]As per the NMS 2011-12 the national estimate of the use of “open” salt was 25%. Hence, an estimate lower than this is considered favorable; and the higher is consistent with worse.

[e]In concurrent presence of the iodine sufficient status as a whole at the population level and an iodine deficient state in one or more quartiles based on the SES, the quartile based (SES) deficiency will be taken into consideration and its pertinent grade will be applied.

Score and risk-grade

Iodine (SAC, NPNLW)
Total score= 4+4+2+1+ 1+1+1+1+4=19
Low risk: ≤ 8; Moderate risk: 9-13; High risk: ≥ 14

5. Results

Examining the above contexts for the key micronutrient status in Bangladesh—such as, magnitude of the serum/urinary deficiency status, quantitative micronutrient intake relative to the EAR and the relative contribution of plant-origin to total intake, geological and programmatic issues with coverage, and the pandemic induced reversal of an otherwise improving dietary quality, the risk-grades are assigned, deducted from allocation of the scores over the parameters of the appraisal. The aggregated scores determined the risk-grades for the probable deterioration of the status of the selected micronutrients back to the reference level (Table 15, 16).

Table 15: Scoring of the risk for the decline of the micronutrient status to the reference level

Micronutrients		Preexisting deficiency	% of population did not meet EAR	% plant based MN to total intake	Geological influence	Programmatic aspects	Programmatic coverage	COVID 19 disruption on the status	Score
Zinc									
Children (2-3 year)		2	2	1	1	1+1=2	-	1	9
Children (4-5 year)		2	2	2	1	1+1=2	-	1	10
NPNL women		3	2	2	1	1+1=2	-	1	11
Vitamin A									
Children (2-5 year)		1	1	1	1	0+1+1=2	1.5*	1	8.5
NPNL women		1	1	2	1	0+1+1=2	2	1	10
Iron									
Children (2-3 year)		1	1	2	-1	1	-	1	5
Children (4-5 year)		1	2	2	-1	1	-	1	6
NPNL women		1	2	2	-1	1	-	1	6
Pregnant women[1]		2	2	2	-1	0	3	1	10
Iron(large cities, Coastal area, Barind)		2	2	2	1	1	-	1	9
Vitamin B12									
NPNL women		1	2	2	1	1+1+1=3	-	1	10
		Preexisting status/ deficiency	Adequately iodized salt	Open salt	Geological influence	Programmatic aspects		COVID 19 disruption of status	Total scores
Iodine									
School age(6-12 year)		2	4	2	1	0+1+1=2	2	1	14
NPPNLW		3	4	2	1	0+1+1=2	2	1	15

[1]Pregnant women are assumed to have higher preexisting ID and similar profile of dietary intake as of NPNL women.

Table 16: Assigning the risk of the decline of the micronutrients status to the reference level as a fallout of the COVID-19 and the possible mechanisms

Micronutrients	Probable pathway	Risk-category (Score)
Zinc	**Pre-COVID-19:** ▪ High existing serum deficiency coupled with sub-optimum dietary intake ▪ Overall low intake, high-plant & low-animal origin intake inversely affect serum status[41,33]	High[a] (9-11)
	COVID-19 & aftermath: ▪ Loss of employment/income with increased food insecurity & poorer diversity of diet, low animal sources foods ▪ Possible nullifying the gains in the quality of micronutrient intakes (e.g. animal sources foods)	
Iron	**Pre-COVID-19:** ▪ Predominantly low burden of ID determined by a fair-to-high amount of wholesome iron consumed through drinking groundwater	Low[b] (5-6)
	COVID-19 & aftermath: ▪ Due to strong influence of the groundwater iron in maintaining the serum iron status, the effect of dietary iron on iron status is small at best as such that some deterioration of dietary intake due to the pandemic-induced issues is unlikely to influence the overall iron status significantly	
	COVID-19 & aftermath: ▪ High risk of ID is anticipated where people have worsened dietary quality as a result of the pandemic & exposed to a very low level of groundwater iron—mainly in underprivileged urban residents, urban new poor of big cities, low-iron containing Barind districts, and the population of the coastal areas extracting water from the deep wells with very low iron level.	High[c] (9)

<table>
<tr><th>Micronutrients</th><th>Probable pathway</th><th>Risk-category (Score)</th></tr>
<tr><td rowspan="2">Vitamin A</td><td>Pre-COVID-19
▪ High serum deficiency (especially in children) coupled with sub-optimum dietary intake
▪ Overall low intake, high-plant & low-animal origin intake (i.e. low bio-conversion overall) inversely affect serum retinol status [40]
▪ Difficult to assess how far has the oil fortification program (supposed to be effective) protected the Vitamin A status in the population in the face of suboptimum level of the fortification standards and coverage[60]</td><td rowspan="2">Moderate[d]
(8.5-10)</td></tr>
<tr><td>COVID-19 & aftermath
▪ Low potential of the traditional diet (highly plant based) to elevate the retinol status
▪ However, possible additional dwindling of the diet quality due to the pandemic might pose additional risk to underprivileged/low SES groups.
▪ Due to reduced earnings caused by the pandemic, more people may use the “bulk/open” oil with suboptimum fortification.
▪ Very high burden of deficiency in the slums poses “high” risk to deline</td></tr>
<tr><td>Iodine</td><td>Pre-COVID-19
▪ High subclinical deficiencies with no appreciable dietary sources
▪ Predominant supply is from iodized salt, persisting suboptimum use of adequately iodized salt [32,4,42]
▪ Poor content of iodine in open salt[43]
▪ Concern that the industrial salt might end up being the edible salt with retailers with uncertain/inadequate iodine level[67]
▪ A number of Divisions reported a high proportion of household salt with zero iodine</td><td>High[e]
(14-15)</td></tr>
</table>

Micronutrients	Probable pathway	Risk-category (Score)
	COVID-19 & aftermath ▪ Favorable actions from the GoB to distribute the salt uninterruptedly. ▪ No issues with premix procurement. ▪ Conversely, the income-depleted people's (Pandemic-induced) likely preference for cheaper open type poorly-iodized salt. ▪ Both these favorable and unwanted discourses during the pandemic along with the existing burden of the subclinical deficiency & persistently high rate of the usage of the inadequately iodized salt would place the nutrient to the pre-pandemic state of the risk of the decline (i.e. reference level) if not worse--pending the strict enforcement of the revised comprehensive salt law.	
Vitamin B12	**Pre-COVID-19** ▪ High serum deficiency coupled with low animal-sourced food intake	High[f] (10)
	COVID-19 & aftermath ▪ Since, animal-sourced food is the exclusive source; the COVID-19 induced loss of employment/income with consequent decrease in food quality is likely to plummet the B12 status, especially among the disadvantaged people.	

[a]High risk for regressing towards the reference time[4]

[b]Low risk of deterioration and the ID status likely to remain consistent with the serum levels of the reference time for most of the population of the country with a fair-to-high level of iron in groundwater[37], (personal communication)

[c]Moderate risk for regressing towards the reference time[4] where iron content in drinking groundwater is very low (<0-0.8 mg/L; personal communication) and/or the water is chemically treated; mostly applies to the underprivileged/slum population residing in the metropolitan cities

[d]Moderate risk for regressing towards the reference time[4]; and likely to remain a public health concern especially in children (subclinical retinol >10%) WHO

[e]High risk for regressing towards the reference time[4]

[f]High risk for regressing towards the reference time[4]

Zinc, vitamin B12 and iodine are assigned with the “High” risk of regressing towards the reference level.[4] With the “High” risk decline potential for iodine, a number of the Divisions with a high rate of usage (>20%) of the household salt devoid of any iodine are forecasted to have a higher risk of the decline of the subclinical status towards the reference or worse (Figure 8). Overall at the country level, Vitamin A is assessed to have the “Moderate” risk of falling back to the level of the reference time. However, the districts with some lagging of the capsule supplementation might be exposed to additional risk. The urban slums with the highest burden of the deficiency are in “High” risk of declining to the reference level (Figure 8). Iron status is adjudicated to receive a “Low” risk in general to deteriorate for the majority of the population; and is likely to remain at the similar good status as of the reference time. However, the underprivileged populations, urban new poor and slum populations of the big cities which have been handicapped by earnings and employment losses and exposed to a very low level of groundwater iron are assessed to have a “High’ risk of the decline, possibly worse than the reference level. In the districts of the Barind-Tract regions (Pabna, Natore, Rajshahi and Chapainawabganj) and the adjoining inland water reservoir areas (i.e. Chalan beal) low-iron groundwater (0-<1 mg/L) is observed consistently. Hence, the pandemic-induced adversaries are likely to push them worse than the reference level of iron status. The populations in the southern coastal areas whose drinking sources are the deep groundwater aquifer with a very low level of iron - are also vulnerable for sliding back inferior to the reference level (Fig 8). Pregnant women with the additional physiological requirement of iron are pitted in a “Moderate” risk of the decline towards the reference level or worse.

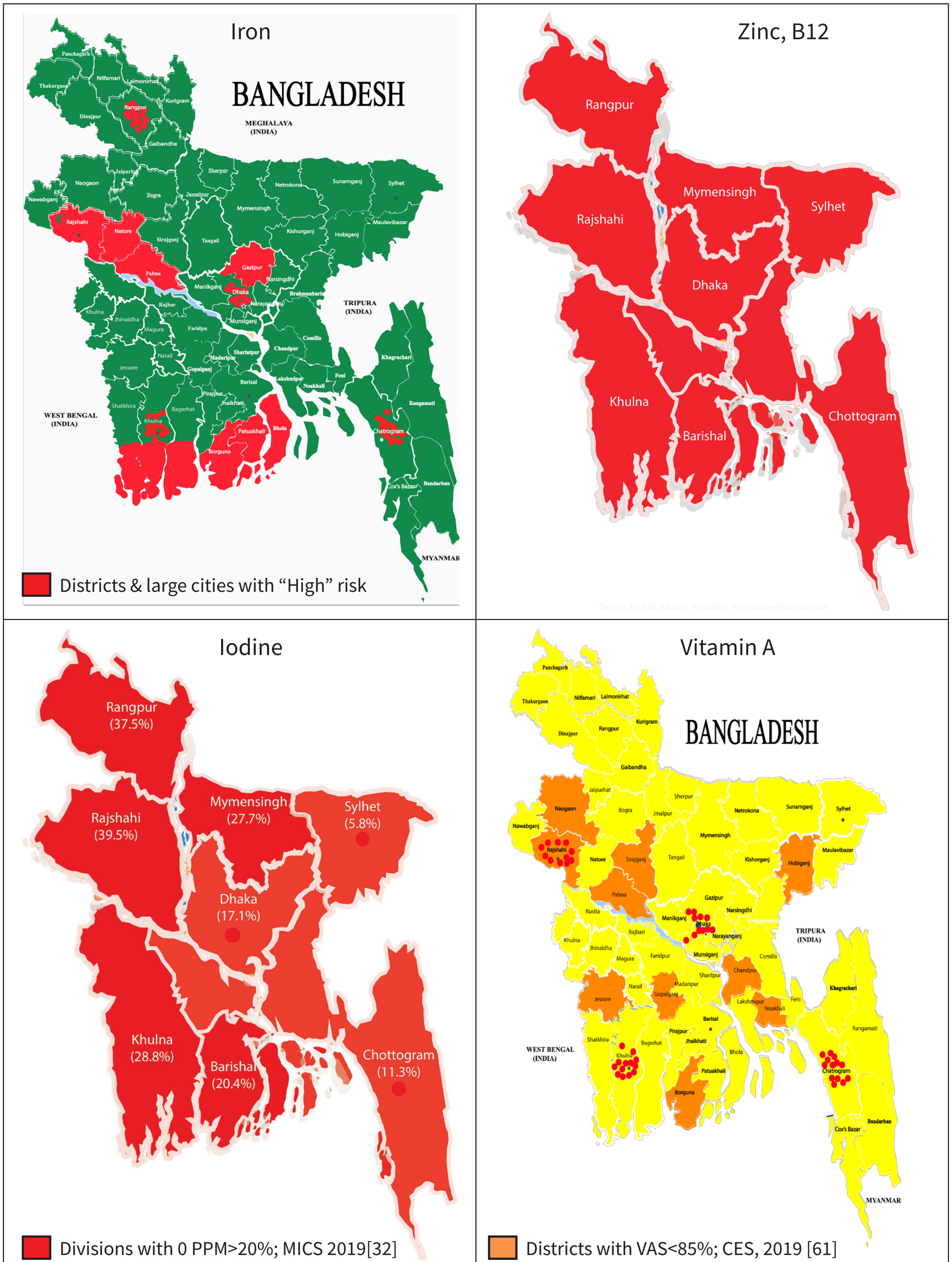


Figure 8 Mapping of the Risk-projection for the declined status of the key micronutrients

Since, the pre-pandemic deficiency of the micronutrients affected the various population groups (children and women) largely with similar magnitudes for most of the nutrients (Table 7); and all are under the same influence of the pandemic-induced intake adversary, programmatic and geological issues, the assessed risk of the decline of the micronutrient status due to the COVID-19 apply similarly across the population groups.

5.1 Is the projected decline of the micronutrient status grounded to the reality?

Any projection/modeling is associated with some degree of inaccuracies. This even applies to sophisticated mathematical modeling. An attempt is made to assess the accuracy of the present contextual appraisal to project the status of some key micronutrients in the aftermath of the pandemic COVID-19.

The preliminary findings of the second national micronutrient survey are disseminated in July 2021. Collection of some data of the survey was done in 2020, hence, it may be assumed that some degree of reflections of the pandemic might have accounted to the reported micronutrients status. However, there are the limitations- the NMS 2011-12 (the reference data) and the NMS 2021 are largely different in design. The NMS 2011-12 had three strata--rural, urban and the urban slums and the national estimates were reported as the function of weights applied at the multiple stages (i.e. 4 stages) of the sampling (NMS 2011-12). On the other hand, the NMS 2021 has the Divisional level estimates and the national estimates. The details of the sampling strategy are expected to be reported in the final report. Secondly, the serum micronutrient status such as, iron, Vitamin A and zinc are influenced by the infection and inflammation and adjustment is needed for inflammation for valid estimates of the micronutrient status. The NMS 2021 preliminary findings did not report on how the micronutrient status was adjusted for infection; while in the NMS 2011-12, a recommended method was applied to adjust the micronutrient status for infection .[68] Despite these limitations, an attempt is made to compare the projected decline of the micronutrient status (i.e. to the NMS 2011-12 level) of a few micronutrients with the reported estimates of the NMS 2021 (Table 17).

Table 17: An assessment of the validity of the projection

NMS 2021	Reference projection time (NMS 2011-12)	Deducted grade of Risk-projection
1 out 2 non-pregnant non lactating women (NPNLW) have zinc deficiency	54% (zinc deficiency in NPNLW)	High
1 out of 3 non-pregnant non lactating women (NPNLW) have iodine deficiency	38% (iodine deficiency in NPNLW)	High
10% rural non-pregnant non lactating women (NPNLW) have iron deficiency	7.1%(iron deficiency in rural NPNLW)	Low

The Table 17 shows that the NMS 2021 reported 1 out of 2 non-pregnant non-lactating women have zinc deficiency. For the pandemic-induced outcome, it was deducted that the projected risk of decline of the zinc status would be “high” to regress back to the NMS 2011-12 reference level. At that time, the prevalence of zinc deficiency in women was 54%, which roughly corresponds to the NMS 2021 findings; and this accounts for some effects due to the pandemic context. Similarly, the NMS 2021 reported 1 in 3 women have the iodine deficiency. The projected decline of the subclinical iodine status due to the pandemic was adjudged to be “high” to falling back to the reference level. During the reference time (NMS 2011-12) the deficiency was 38% which roughly corresponded with the NMS 2021 estimates. Hence, despite the limitations stated above, it is envisaged that the pandemic induced projection of the declining micronutrient status presented in this study has a fair degree of accuracy.

6. Limitation and Strength

Customary to the projection studies, the present appraisal has the limitation. Determining the status of micronutrients is complex, and there are the interactions within the body system.[69] Hence its projection to a specified level is far from being straightforward. The assumptions behind the present projection might change over time, due to changes in the underlying contexts (e.g. socio-economic, pandemic control measures etc) which may affect the intakes and serum status of micronutrients. Hence, some degrees of inaccuracies in terms of the projected changes of the serum status may not be ruled out.

The Government of Bangladesh has promptly embarked upon some macro-level initiatives to tackle the situation.[12] Such as, the fiscal-monetary sustenance for farmers, food and cash relief, and selling food items with subsidy and expansion of the safety net programs. These prompt mitigation drives at the national level may revert to some extent the projected declines of the micronutrient malnutrition. Nonetheless, a recent report suggests that the national social safety net programs often not able to target the actual poor, and many of them remained excluded.[23] Hence, the benefits might not be reached to all who are in need the most.

6.1 The inflammatory effects of the SARS-COV-2 on the micronutrient status

Presence of infection/inflammation inflates serum ferritin and deflates serum retinol and zinc status.[70,71] It is infeasible to decipher how many of the nearly 170 million population of Bangladesh have been affected with SARS-COV-2 virus; nonetheless the most recent estimates suggest approximately 1.2 million of the diagnosed cases which is less than 1% of the total population. The NMS 2011-12 on the nationally representative data reported that in 14% of the adult population had the elevated level of alpha-acetylated glycoprotein (AGP) signifying the presence of infection/inflammation. If the estimate is considered an average burden of the common infections, considering the fact that some overlapping of the SARS-COV-2 and other infections are inevitable; and the nominal <1 % of the population are the documented COVID-19 cases, it is unlikely that there is a significant increment of the elevated infection burden due to the COVID-19 (i.e. at the infection-biomarker level) at the nationally representative level. Additionally, the inflammation-adjusted mean ferritin is about 4 times the cut-off (15 ng/ml) defining the iron deficiency. Hence, any upping of the ferritin for the COVID-19 if consequently down-adjusted to correct, it would have been highly unlikely to plummet the ferritin level below the cut-off. Hence no appreciable effect is envisaged on ID due to the SARS-COV-2. This notion is complemented by the fact that the preliminary findings of the NMS 2021 micronutrients status data, the collection of which somewhat coincided to the pandemic context did not considerably deviate from the projected micronutrient status. Nonetheless, the accurate quantification of the SARS-COV-2 virus related confounding of the micronutrient status was beyond the scope of the study, and this constitutes a limitation.

The strength of the appraisal underpins that it is founded on some key outcomes in the aftermath of COVID-19 which are actually measured in the country, during the first and the second surges of the disease, e.g. loss of work/income, increased food insecurity, increased food price, poor dietary diversity and food intake. The association of these outcomes and nutritional/ micronutrient status is extensively proven globally. Furthermore, the evaluation was done by examining the objective contextual factors-- the quantitative intake profile of the micronutrients, preexisting serum status, gains in the quality of food intake over the time alongside its reversal for the pandemic, and the environmental and micronutrient programmatic issues giving it the robustness. Furthermore, the strength of the projection lies on a sound conceptual framework, an appraisal of the influence of inflammation/infection on micronutrient status and verification with the pandemic-time nationally representative data.

7. Conclusion & recommendation

In conclusion, on the backdrop of the COVID-19, the prospective status of the key micronutrients in Bangladeshi population suggests a varied outlook. Zinc, iodine and vitamin B12 forecast a "High" risk of the regress towards the reference period. Overall, Vitamin A, poses a "Moderate" risk of sliding back to the reference time. But the risk in urban-slum areas would be "High". Generally iron poses a "Low" risk of the decline in the serum and might be remaining at the similar good status as of the reference time for most of the population of the country. However, the disadvantaged population—1) in the large cities hard-hit by the financial strains and exposed to very low levels of groundwater iron; 2) the low-iron containing ground waters in the Barind-Tract areas; and 3) the population in the southern coastal areas who are exposed to a very low level of groundwater iron are pitted in a "High" risk of the decline perhaps worse than the reference time. Pregnant women are exposed to a "Moderate" risk of decline towards the reference level or worse. The approach of the projection of micronutrient status can be replicated in other settings in a pandemic context or large scale calamities compromising income, food security and dietary intake.

7.1 General recommendations

Operational

1. Establish a system to better manage the availability of and access to the animal source foods (ASF) –i.e. producers can sell & poor can access to in a mutual win-win matter at the time of the calamities like COVID-19 pandemic [Short & Mid-term].
2. Strict monitoring and implementation of the concerned fortification/supplementation laws [Ongoing]

Policy-level

1. Explore the ways for the improved targeting of the Social Safety Net (SSN) [Short-term].
2. Coordination of the concerned departments about the various micronutrient interventions (i.e. fortification, bio-fortification, supplementation)--so the needs for the micronutrients are met and not exceeded [Mid & Long-term].
3. Provision of the Multiple Micronutrient Supplement (MMS) for pregnant women and adolescents, Micronutrient Powder (MNP) for children in poor, new poor and food insecure populations [Short & Mid term].

7.2 Specific recommendations

Zinc

Policy-level

1. Expansion of the SSN with multiple micronutrient-fortified rice containing zinc. This intervention may be expanded for poor population e.g. urban slum poor/new poor [Short-term].

2. Enabling the access to the animal source foods (ASF) for the income poor [Short & Mid-term].
3. Improved varieties of the zinc bio-fortified rice to undergo further scientific assessment and promotion [Mid & Long-term].

Iodine

Operational

1. Prompt and effective implementation of the salt law 2021, including strict countrywide monitoring, especially in the low performing divisions [Short & Mid-term].

Policy-level

1. Temporary provision of iodized packet salt in the food-basket for the poor/new-poor [Short-term]

Vitamin B12

Policy-level

1. Enabling access to the ASF for the income poor/new-poor [Short-term].

Vitamin A

Operational

1. Heightened monitoring of the oil fortification standards and penalty for breeches [Short & Mid-term].

Policy-level

1. Enabling the access to the ASF for the income poor/new poor [Short-term].
2. Temporary provision of vitamin A fortified bottled oil in the food basket for the poor/new poor
3. Urban slums need additional focus on the recommended activities [Short & Mid- term].

Iron

Operational

1. MMS/IFA should have uninterrupted supply all over the country [Short-term].

Policy-level

1. No major intervention (in the predominantly rural settings) is required
2. For large cities, low groundwater iron containing Barind Tract districts or in the coastal belt areas (where iron content is very low in groundwater), expansion of and inclusion in the SSN or other similar schemes of the multiple micronutrient-fortified rice containing iron [Short & Mid-term].

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Annexures

Annex 1: Government order for formation of "Expert Committee" for developing Micronutrient Impact assessment report.

গণপ্রজাতন্ত্রী বাংলাদেশ সরকার
বাংলাদেশ জাতীয় পুষ্টি পরিষদ কার্যালয়
আইপিএইচ ভবন (৩য় তলা), মহাখালী, ঢাকা-১২১২।
Email: dgbnncbd@gmail.com, ফোন-০২-২২২২৬১৮২৯
ওয়েবসাইট:http://bnnc.gov.bd

স্মারক নং:ঃ বাজাপুপ/এম এন্ড ই/১১-৫৪/২০১৮/৮৪ তারিখঃ ০৬/০৫/২০২১ ইং

বাংলাদেশের জনগণের পুষ্টির মান উন্নয়নের জন্য পুষ্টি বিষয়ক গবেষণা কার্যক্রম পরিচালনা এবং জনগণের Covid-19 পরবর্তী Micronutrient পরিস্থিতি নির্ধারণের লক্ষ্যে নিম্নলিখিত সদস্যগণের সমন্বয়ে একটি 'Expert Committee on Micronutrient Impact Assessment' গঠন করা হলঃ

১। ডাঃ মোঃ খলিলুর রহমান মহাপরিচালক বাংলাদেশ জাতীয় পুষ্টি পরিষদ,	সভাপতি
২। ডাঃ এ এফ এম ইকবাল কবির, পরামর্শক, বি এন এন সি	সদস্য
৩। ডাঃ তাহমিদ আহমেদ, এক্সিকিউটিভ ডিরেক্টর, আই সি ডিডি আর বি	সদস্য
৪। অধ্যাপক নাজমা শাহীন, খাদ্য ও পুষ্টি বিজ্ঞান ইন্সটিটিউট, ঢাকা বিশ্ববিদ্যালয়	সদস্য
৫। ডাঃ ফারজানা রহমান, উপ পরিচালক, বাংলাদেশ জাতীয় পুষ্টি পরিষদ	সদস্য
৬। ডাঃ গাজী আহমেদ হাসান, ডিপিএম, জাতীয় পুষ্টি সেবা	সদস্য
৭। ডাঃ মোঃ মহসিন আলী, কনসালটেন্ট, পরামর্শক, বি এন এন সি	সদস্য
৮। ডাঃ সবুক্তগীন রহমান (গ্রিফিথ বিশ্ববিদ্যালয়),নিউট্রিশন স্পেশালিস্ট ও পরামর্শক, বাংলাদেশ জাতীয় পুষ্টি পরিষদ	সদস্য
৯। ডাঃ রুদাবা খন্দকার, Country Director, GAIN, Bangladesh	সদস্য
১০। ড. সানথিয়া আইরীন,ডেপুটি কান্ট্রি ডিরেক্টর, , Alive and Thrive, FHI360, Bangladesh	সদস্য
১১। ড. মাহফুজার রহমান, কান্ট্রি ডিরেক্টর, পিওর আর্থ, বাংলাদেশ	সদস্য
১২। ডাঃ মোঃ গোলাম মহিউদ্দীন খান সাদী, নিউট্রিশন স্পেশালিস্ট, ইউনিসেফ	সদস্য
১৩। সাইকা সিরাজ, Country Director, Nutriton International, Bangladesh	সদস্য
১৪। তনিমা শারমিন, নিউট্রিশন স্পেশালিস্ট, World Food Program	সদস্য
১৫। ফারহানা শারমিন, পরামর্শক, WHO	সদস্য
১৬। মোঃ হাবিবুর রহমান, প্রোগ্রাম অফিসার, বাংলাদেশ জাতীয় পুষ্টি পরিষদ	সদস্য
১৭। ডাঃ মোঃ আকতার ইমাম, উপ পরিচালক, বাংলাদেশ জাতীয় পুষ্টি পরিষদ	সদস্য সচিব

কার্যপরিধিঃ

১। Covid-19 পরবর্তী Micronutrient Impact Assessment' এর জন্য প্রয়োজনীয় পর্যালোচনা, ও গবেষণার জন্য কার্যকর ব্যবস্থা গ্রহণ করা।

২। Micronutrient deficiency মোকাবিলায় বহুখাতভিত্তিক কার্যক্রম সমন্বয়ে নীতিগত দিকনির্দেশনা প্রণয়ন করা।

৩। ঝুকিপূর্ণ জনগোষ্ঠীর বিশেষত নারী ও শিশুদের কোবিড-১৯ পরবর্তী Micronutrient deficiency মোকাবিলায় প্রয়োজনীয় পরামর্শ ও সহযোগিতা প্রদান করা

৪। ঝুঁকি-ঘাটতিতে থাকা অনুপুষ্টি সমূহের মান উন্নয়ন এবং অনুপুষ্টি ফর্টিফিকেশন প্রোগ্রাম সমূহের পরিবীক্ষণ ও মূল্যায়ন ব্যবস্থার উন্নয়নে প্রয়োজনীয় দিক নির্দেশনা প্রদান করা।

৫। কমিটি যেকোন সময় সভায় মিলিত হতে পারবেন এবং প্রয়োজনীয় সংখ্যক সদস্য কো-অপ্ট করতে পারবেন।

ডাঃ মোঃ খলিলুর রহমান
মহাপরিচালক
বাংলাদেশ জাতীয় পুষ্টি পরিষদ কার্যালয়
মহাখালী, ঢাকা- ১২১২।

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For more information:

Bangladesh National Nutrition Council (BNNC) Office
IPH Building, 2nd Floor
Mohakhali, Dhaka 1212
Telephone: +88-02-222263007
Email: dgbnncbd@gmail.com
Website: www.bnnc.gov.bd

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