Review article

Potential Fallout of the COVID 19 Pandemic on the Status of the Selected Micronutrients in Bangladesh Population: A Contextual Appraisal

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Abstract

The pandemic of the SARS-COV-2 (COVID 19) has been inflicting significant toll on employment, income and dietary intake in the population of Bangladesh. As a result the nutritional status of the population is under stress. As a developing country the burden of micronutrient malnutrition had been perverse. The ongoing pandemic might have worsened the condition; hence the present study attempted to project the risk of decline of the status of some key micronutrients. A contextual review was conducted. A reference level of the pre-pandemic micronutrient status was identified. A thorough appraisal was done considering the prevalent serum micronutrient status, micronutrient intakes, food sources, geological issues affecting the micronutrient status and the programmatic issues. A qualitative risk-category was assigned for the sliding back of the micronutrient status to the reference level. A mixed outlook of the key micronutrient status was observed due to the pandemic-related consequences on food security and intake. Appropriate mix of coordinated interventions need to be planned, customized and operationalized.

Keywords: Micronutrient, Projection, COVID 19, Bangladesh

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 eight months; and currently is placed among the countries with the highest number of the detected cases (Worldometer 2020). The COVID 19 has been inflicting significant non-clinical adversities with regard to employment, food consumption, food security and nutritional status globally, and Bangladesh is no exception.

1.1 Effect of COVID 19 on income and household food insecurity in Bangladesh

A nationally representative survey in the country reported, in the first month into the lockdown, compared to the Pre-COVID 19 period (February 2020) overall, 63% of the main-earners in families were rendered inactive. Compared to the reference time, income dropped by 75% in urban slums and 63% in rural settings, the survey reported. Some 71 % of the urban respondents and 55% of rural respondents experienced uncertainty of livelihood. Proportion of households reporting reduced food intake was 47% and 32% in urban slums and rural areas respectively (Rahman HZ 2020). Hamadani et al with a pre-post study design has captured 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 reported that the median monthly income of the same families fell 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 (Hamadani 2020). Another study in a rural and an urban slum setting, which took data over the first month into the lockdown reported 88% households experiencing any form of household food insecurity (personal communication). In addition, people were embracing various coping strategies to manage household food insecurity—e.g. by curtailing on foods, selling assets, borrowing from others. Many reasonably well-off people have resorted to become vendors, vegetable sellers or food sellers to earn money (BNNC 2020).

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

Low family income/wealth status is associated with household food insecurity (Harris-Fry 2015, Esturk 2013). Household food insecurity in turn is associated with low dietary diversity (Chandrasekhar 2017) implying monotonous, nutrient-poor and cheap foods. Household food insecurity is further associated with micronutrient intake and/or status. Studies have shown that the micronutrient intake and the serum status are lower in food insecure households compared to food secure households (Dixon 2001, Skalicky 2006). Hanson et al has shown that food-insecure adults consumed fewer vegetables, fruit, and dairy products than did food secure adults and had lower intake of vitamins A and B-6, calcium, magnesium, and zinc (Hanson 2014).

1.3 Rationale

The pandemic has affected adversely on people's income, employment and food security in Bangladesh. The above evidence raises the concern that the low financial and food wellbeing might have a deleterious effect on the micronutrient status of the Bangladeshi population. On the other hand, underscoring the significance of the COVID 19 associated fallout of undernutrition in population, Bangladesh National Nutrition Council (BNNC) -- the apex body of the country's nutritional policies led an appraisal for the projection of under nutrition (BNNC 2020). However, the assessment was limited in the projection of acute malnutrition. The present paper attempted to do a risk appraisal of the decline of the status of some selected micronutrients in the prevailing context of the COVID 19.

2. Methodology

Essentially the method was a thorough contextual appraisal to understand the micronutrient status of the pre-pandemic period and the underlying factors including the intake profiles and programmatic and structural issues. The process includes identification of a pre-pandemic reference data and assessment of risks of some micronutrient statuses falling back towards that level through a battery of specific technical and programmatic assessments in conjunction with the pandemic-induced depletions in income, food security and food intake.

Firstly (in the introduction) an appraisal of the studies was done on how the Covid-19 associated restrictions affected the income, employment, food security and food intake in Bangladesh populations.

Secondly, a 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 a reference survey/study to aid 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 country context.

Fourthly, the appraisal of the pre-pandemic status of the selected micronutrients was done considering the quantitative intake of micronutrients, nutrient gaps, type of sources (plant vs. animal source foods); and the concomitant serum/urine statuses of the micronutrients. The appraisal considered the environmental/structural issues pertaining to specific micronutrient which determines its status. A thorough assessment of the programmatic issues was included for some relevant micronutrients (pre- and during the pandemic) (Fig. 1).

Finally, following the appraisal over these issues, some provisional “risk-grades” were assigned to project the COVID 19 associated probable fallout of the selected micronutrients status regressing to the reference level.

2.1 Review of the studies and selection of the reference data for the projection

A pre-post comparative assessment for the impact of the COVID 19 on the serum micronutrient status is the method of choice. However, during this unfavorable juncture, data is unavailable on the population-level micronutrient status in the aftermath of the COVID 19. Ideally, the optimum appraisal of micronutrients status for a nation requires having 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 review was undertaken of the surveys and studies conducted over the pre-pandemic period. A number of large nationally representative surveys were considered which studied the dietary/micronutrient intakes and serum micronutrient status. Further, a brief review of Bangladesh-based studies was undertaken encompassing a period of 2010-2020 on the Pubmed database. 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 and thus were considered for the appraisal. Additionally, a few of the ongoing/unpublished studies were appraised concerning dietary intakes.

Table1: Contemporary National Surveys and Studies Concerning Micronutrients in Bangladesh over the Last Decade (2010-2020)

Surveys/Studies	Serum micronutrients	Anemia	Quantitative MN Intakes	Quantitative food intake	Qualitative food intake
National Surveys					
MICS 2019	×	×	×	×	√
BDHS 2017	×	×	×	×	√
HIES 2016	×	×	×	√	×
BDHS 2014	×	×	×	×	√
NMS 2011-12	√	√	√	√	√
BDHS 2011	×	√	×	×	√
HIES 2010	×	×	×	√	×
Local/Sub-national studies/surveys					
Iqbal 2019	NR*	√	√	√	√
G. Ara 2019	√ (Zinc only)	√	×	×	√
Nguyen 2017 ^{II}	×	×	√	√	×
Nguyen 2018 ^{II}	×	×	√	√	√
Stewart 2019 [‡]	√	√	×	×	×

McCormick 2019 [§]	✓	✓	✓	✓	×
Sanin 2018	×	×	✓	✓	×
Mustafa, 2020	×	×	✓	×	×
Leyvraz 2016	✓	✓	✓	✓	×
Muttaquina 2019	×	✓	×	×	×
INFS (2017-18) (Personal comm.)	×	×	(Personal Comm.)	(Personal omm.) †	NR*
Jivita Cohort for adolescents (2019) (Personal Comm.)	✓	✓	NR*	NR*	NR*

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*NR (Non-Reported): Either absent or unpublished

†Animal-sourced foods; §data-period (2009-2014); ‡data-period (2012-13); || data-period (2015-16); ¶ data-period (2015)

Among the localized studies—G. Ara et al, Nguyen et al, Nguyen et al, Stewart et al, Muttaquina et al, and Mustafa et al do not meet both of the two critical parameters of appraisal - serum micronutrients and the quantitative micronutrient intakes. The major nationally representative surveys, e.g. Bangladesh Demographic Health Surveys 2017, 2014, 2011 have not reported the serum micronutrients or the quantitative micronutrient intakes—but on the qualitative dietary intakes. The BDHS 2011 reported the anemia prevalence. The Household Income and Expenditure Surveys 2016, 2010 reported only 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. By far, the National Micronutrient Status Survey 2011-12 reported all the considered parameters for the appraisal on multiple population groups on a nationally representative scale. Despite the survey being somewhat older, it was the most comprehensive for an optimum appraisal of the micronutrient status of the country. Interestingly, when this national survey is compared with some recent (conducted

short interval prior to the pandemic) studies, the intake estimates of the micronutrients appear not largely different and reasonably consistent accounting for the varied designs (national survey vs. localized studies; SQFFQ vs. 24h-Recalls) and population structures of the studies (Table 2).

Table 2: Comparative intakes of the selected nutrients between the NMS 2011-12 & recent pre-COVID 19 studies

Survey/Studies	Settings	Data collection	Vitamin A (µg RAE/d)	Iron (mg/d)	Zinc (mg/d)
NMS 2011-12*	National Survey	2011-12	270.4	4.1	3.1
Rahman 2019†	Rural northern sub district	2018	299.0	3.6	5.3
Iqbal 2019‡	Dhaka slum	2016	472.5	3.8	2.8
Sanin 2018§	Dhaka slum	2016	63.2	1.59	1.27
Mustafa 2020	Dhaka slum	2016-2018	57.8	2.2	1.3

*Children aged 24-59 mo

†Children aged 24-59 mo

‡Children 24-36 mo old

§Children 12-24 mo

||Children 12-18 mo; Length-for-Age Z-score<-1

However it is envisaged that over the last several years, Bangladesh has manifested a progress in dietary quality alongside the increase of people's purchasing capacity. The Household Income and Expenditure Survey 2016 reported that at the national level there was the substantial increase in the consumption of meat (+33.3%), eggs (+87.3%) and fishes (+26.8%) compared with that of the 2010 round. Over the same period the intake of cereals such as rice consumption 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. An ongoing study being conducted by the Institute of Nutrition and Food Science, University of Dhaka has estimated that the intake of animal sources food and micronutrients increased considerably (personal communication) (Table 1). A recent cohort study among the adolescent population of a northern district suggested that anemia has decreased compared with the 2011-12 national micronutrient survey estimates. Iron Deficiency (ID) was negligible (concomitant to high level of iron from drinking groundwater). The serum status of other micronutrients, e.g. zinc, folate, vitamin B12 and

vitamin D has shown improved status compared to the estimates of the national micronutrient survey 2011-12 (Supplementary Table 1). But the study did not report the quantitative micronutrient intakes (Jivita Cohort Study; personal communication, Table 1). Therefore, appraising these national surveys and studies, the nationally representative national micronutrient survey 2011-12 with its complete repertoire of serum nutrients and the quantitative intakes, comparability of some nutrient intakes with recent studies; and an exhaustive multivariable analyses studying the association of the micronutrient intake and serum status (Leyvraz 2016, Rahman 2016, Rahman 2016, Rahman 2016), offers the most suitable proxy to the pre-COVID 19 reference data.

Though the above review of literature did not return any studies on iodine intake/fortification, we considered the recent Multiple Indicator Cluster Sampling Survey 2019, published just before the pandemic for the salt iodization data. Interestingly, as per the survey the prevalence of usage of the adequately iodized salt (>15 ppm) was 58.5%. The estimate was consistent with 57.6% reported in the national micronutrient survey 2011-12, rationalizing the micronutrient survey as the pre-pandemic reference data for iodine alongside some other studies conducted during the interval times (MICS 2019, Knowles 2017, Knowles 2018).

2.2 General principle/concept behind 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.

a. Intake aspect

Some of the above data exemplify that the quality of diet has improved over the last several years. However, it is difficult to assess and ascertain from available data that the corresponding quantitative increment of the intakes of micronutrients has occurred. Further, in absence of an updated data segregated 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.

b. Serum micronutrient aspect

The above review suggests that there is a scarcity of recent data on serum micronutrients within a short interval (e.g. 1 year) prior to the onset of the pandemic. The only available data pertaining to that period is the Jivita cohorts study which in comparison to the NMS 2011-12 reported some improvement of serum statuses for some micronutrients (zinc, iron, folate, B12, vitamin D) and improvement in the prevalence of anemia in a rural setting of Bangladesh (Supplementary Table 1). Although the study lacked the quantitative micronutrient intake data, we assume that the gradual increase in the dietary quality due to the mentionable increase in food production especially poultry, fish, vegetables over the last decade has impacted that improvement in the serum micronutrient statuses even in a remote rural setting.

Therefore, we predict that the recent dwindling of peoples employments, earnings (Supplementary Table 2) and heightened food insecurities in conjunction with the COVID 19 pandemic might have offset the gains in the improving dietary intakes over the years and plausibly resulted in the serum micronutrient status regressed back to the 2011-12 level.

Table 3: Status of the selected micronutrient deficiencies considered as the reference data (NMS 2011-12)

Micronutrient deficiency	% (95% CI)
Vitamin A	
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	
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	
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	
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)

2.3 Micronutrients considered for the appraisal

Four of the most important micronutrients of public health significance 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 (Watanabe 2007), which during the restricted economic activities due to the COVID 19 has a strong propensity to have the decreased intake.

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

1. *The pre-COVID 19 deficiency status of the micronutrients, i.e. reference data (Table 3):* The estimates were used as the magnitude of the preexisting deficiencies and to assess the degree of the projected risk.
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 required dietary allowance (RDA). The intake as the relative proportion of RDAs was used for the risk-grading of serum deficiencies.
3. *Relative attribution of food sources for the intake of the index micronutrients:* Reference survey data was used to appraise the relative contributions of the plant-sourced (low bioavailable) vs. animal-sourced (higher bioavailability) micronutrients. Relative proportions were used to assess the projected risk.
4. *Reflection of the environmental/geological factors affecting the status of the micronutrients (e.g. groundwater iron):* The environmental geological factor was relevant for iron. Groundwater is the principal potable supply in the country and contains predominantly a high but variable amount of iron (British Geological Survey 2001, Bangladesh National Drinking Water Quality Survey, 2009). Groundwater iron is positively associated with ferritin concentration in population (Merrill 2011, Rahman 2016). It was considered in assessing the projected risk of the decline of the iron status. Environmental factors also influence iodine as the country is plain and riverine with significant washout effects for iodine in the soil (Pandav 2017).
5. *Consideration of any fortification/supplementation programs:* National mandatory edible oil fortification program of vitamin A was appraised to complement the probable risk-grading of vitamin A deficiency. Salt iodization program was appraised during and the pre-pandemic time.
6. *The determinants affecting the serum micronutrients in Bangladesh context (analyses from the national micronutrient survey 2011-12):* The present appraisal has a basis on the multivariable analyses which identified the key determinants of serum micronutrient level, derived from analyzing the national micronutrient survey 2011-12, i.e. the reference data (Rahman 2016, Rahman 2016, Rahman 2016). The analysis identified some key determinants—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 nutrients respectively. The Fig. 1 depicts the derangements in people's

food security and food intake as the consequence of the pandemic, the reference data for the micronutrient projection; and the technical and programmatic elements that aid in the projection.

Figure 1: Conceptual assessment of the risk of the decline of micronutrient status in the context of Bangladesh due to the Covid 19 pandemic

Finally, after appraisal over the considered factors, a provisional categorization of potential risk of the decline of the micronutrients was done. The risk-classification is qualitative and arbitrary—“High”, “Moderate” and “Low”; and implies respectively the “high”, “moderate” and “low” risks of the decline of the subclinical status towards the reference time status (NMS 2011-12).

Appraisal of the selected micronutrients: Discussion and Results

3.1 Zinc

Bangladesh has a high burden of the pre-COVID 19 zinc deficiency—44.6% in preschool age children and 57.3% in women (National Micronutrient Survey 2011-12) (Table 3). The proportion of the children aged 2-5 years meeting RDA is 11.4-44.7% and the non-pregnant non-lactating women meeting RDA is 0.5-6.4% (National Micronutrient Survey 2011-12, Rahman 2016). More than two-thirds of this inadequate intake comes from plant sources rendering them poorly bioavailable. Patterns of this intake remained largely unchanged as suggested by the recent study (Iqbal 2019, Sanin 2018, Rahman 2019). 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 negatively (Rahman 2016). Hence, with the impact of COVID 19 with a potential compromise of the access to zinc rich food (e.g. animal source foods) and reduced dietary diversity in the low SES populations, the plight of zinc status looks bleak.

3.2 Iron

Iron depicts an interesting scenario. Similar to zinc, the dietary intake of iron in the populations are sub optimum. Mean intake of dietary iron in children 2-5 years old is 4.59 mg/day (National Micronutrient Survey 2011-12) falling fairly short of the RDAs as per the age subgroups (7-10 mg/day) (Institute of Medicine 2002). The relative intake in women is further lower. A meager 3-6% of the children met the RDA (National Micronutrient Survey 2011-12) for iron and the large majority of the intake comes from plant sources in a cereal based dietary system with a poor bio-availability. The intake remained largely indifferent as reported in the recent study (Iqbal 2019, Sanin 2018, Rahman 2019). Interestingly, unlike the zinc status, the national prevalence of iron

deficiency is low—7-10% in the preschool children and non-pregnant women (Table 3). Further, in a recent large birth-cohort study the prevalence of ID in 9-13 years old children was 0.5% (Personal communication). The reason for this low prevalence of iron deficiency despite consuming grossly sub optimum dietary iron is the iron obtained from groundwater, the predominant drinking source of the population (Merrill 2011, Rahman 2019, Rahman 2019, Rahman 2016). This iron from drinking water maintains a satisfactory infection-adjusted serum ferritin well above (~3-4 times) the cut-off point defining iron deficiency (National Micronutrient Survey 2011-12). The influence of dietary iron on serum ferritin status is negligible compared to that of high groundwater iron. This is evident from a recent trial of testing the efficacy of an iron-containing micronutrient formulation on ferritin status in Bangladeshi children exposed to high groundwater iron. The study showed that the children (2-5 years) upon receiving 12.5 mg iron every day for 2 months (~85% compliance) had the infection-adjusted ferritin levels remained largely indifferent (67 ng/ml at baseline vs. 72 ng/ml; $p=ns$) (Rahman 2019). This owes to the fact that when the body reserve of iron is sufficient, exogenous absorption of iron gets limited as the hepcidin - mediated negative feedback regulation is activated (Saito 2014). Dietary intake of iron was well below the RDAs and remained statistically unchanged (3.15 mg/d at baseline vs. 3.3 mg/d at end line; $p=ns$). For women, Merrill et al (2011) has shown that in a high groundwater iron setting, the median intake of iron from groundwater was 42 mg/day which is close to the upper level of tolerable intake for iron (45 mg/day) as defined by a joint WHO/FAO technical committee (WHO 2004). The above illustrations clearly demonstrate the dominant influence of groundwater iron in population iron status.

Taking into consideration the above findings, it is apparent that the probable dietary limitation resulting from COVID 19 would unlikely to adversely impact the serum iron status in the overall populations--simply 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.

3.3 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 (WHO 2011); was 20.5%, 20.3% and 5.4% in preschool children, school age children and non-pregnant non-lactating women of the reproductive age respectively (Table 3). The magnitude of the deficiency is particularly high in children of both age groups which were further higher in the slums population (National Micronutrient Survey 2011-12). Complementing the infection-adjusted high retinol deficiency, the dietary intakes of vitamin A was sub optimum across the population groups. Only around one-thirds of the preschool age children and women met the RDA for vitamin A. 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 (Rahman 2016). Intake of higher bioavailable animal-source vitamin A was 5-10 % of RDA in children and non-pregnant women. Intake of animal sourced food was a strong predictor of both the total and animal-sourced vitamin A (Rahman 2016). However, with the predominantly plant based vitamin A sources, the population level status has largely remained stagnant over the decades (between 1997 & 2011), suggesting a weak potential of the traditional diet to improve the retinol status (Rahman 2016). However, with COVID 19, the worsening of the food security and agricultural food supply, especially in the underprivileged population some deterioration 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 (OPM/IDS/GAIN 2020); though the piloting of the fortification of oil had started following the national micronutrient survey 2011-12. Vitamin A fortificant—retinol 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 on edible oil (2017) found that only 41% of bulk oil (non-bottled) was assessed to be fortified with vitamin A (GAIN/icddr 2017). A very recent 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 meager 7% of the samples meeting the standard ⁽⁴⁶⁾. 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 considerably cheaper (BDT 15-20 less per liter) than the bottled oil (Mbuya 2020) - a fact that will push additional people to purchase the oil due to the pandemic induced income reduction. 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 (Rahman 2016) as evidenced from the measures of the two-nationally representative surveys (HKI/IPHN 1999, National Micronutrient Survey 2011-12) conducted more than a decade apart. Over these surveys the prevalence of subclinical vitamin A deficiency was 21.7% and 20.5% in the preschool age children respectively amid the presence of the national supplementation program. Moreover, its effects on serum retinol do not last more than 3-4 months in this population (Rahman 2016). Though the national campaign on vitamin A supplementation has taken place recently in the aftermath of the pandemic, considering the above observation, its importance for population-level (preschool children) vitamin A nutriture is not as important as the vitamin A fortification of edible oil program. 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.

3.4 Iodine

Iodine is a key micronutrient, however 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 as well as the programmatic issues to determine the post-COVID 19 outlook of the nutrient.

The pre-pandemic status of the population level subclinical iodine deficiency was consistent with a public health concern. In the school age children, the deficiency was 33.8% (Yusuf 2008) & 40% (National Micronutrient Survey 2011-12) and in non-pregnant-non-lactating women 38.6%

(Yusuf 2008) & 42.1% (National Micronutrient Survey 2011-12). To complement these estimates the national usage of adequately iodized salt (>15 ppm) was 57.6% (National Micronutrient Survey 2011-12), 50.5% (Knowles 2017) and 58.5% (MICS 2019). The household usage of the adequately iodized salt was just 35% in the poorest SES (MICS 2019). These estimates are at a considerable distance off the National Plan of Action for Nutrition 2 (NPAN 2) target of 90% which needs to be achieved by 2025 (NPAN2, GoB, 2017). Usage of the open/loose salt at the rural areas was ~25% which increased to 37% among the poorest households (National Micronutrient Survey 2011-12). Conducted in 2015, Knowles et al have shown from a nationally representative survey to examine the iodization of salt, that the packaged salt contained 3.8 times more iodine than the open salt (Knowles 2018).

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 (Ministry of Commerce, GoB, 2020). The procurement of the premix (KIO_3) was optimum and unaffected by the pandemic (BSIIS 2020). This is evident from the fact that trend of the salt production and premix procurement in the first 6 months of 2020 (lockdown time included) was consistent over the same months of the preceding year (2019) (Fig. 2).

Fig 2: The trend of the production of salt and the procurement of the premix over 2019 & 2020

Fig 2 depicts the 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 (Bangladesh Bureau of Statistics, 2020), however, the price of the coarse salt (produced by small millers) is considerably cheaper; about one-half or less that of the package salts (OPM/IDS/GAIN 2020). There are multiple 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 (OPM/IDS/GAIN 2020).

The 2015 survey observed that households more vulnerable to poverty were shown to be 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 (Knowles 2018). As per the national micronutrient survey 2011-12 the bottom 40% of non pregnant women population according to the SES had the median urinary iodine <100 µg/l, hence they were sub clinically deficient with iodine (National Micronutrient Survey 2011-12). Henceforth, during this pandemic the underprivileged people hard-hit by the financial crunches are more likely to purchase the “cheap” salt, with the potential for further spiraling of iodine nutriture. However, on the positive note, a revision of the salt law is upcoming with modifications—such as more clarity in packaging, narrower range of iodization at the plant level (45-50 ppm), and stricter punitive measures for the breeches (OPM/IDS/GAIN 2020). The law has the potential for promoting the usage of the adequately iodized salt. Further, as part of the Government’s response to the pandemic, packet iodized salt was included in the emergency food package distributed among poorer population (BNNC 2020).

Nonetheless, 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) poorer people for the cheaper sub optimally iodized salt, the immediate fallout for the iodine nutrition looks unfavorable, pending the inception and optimum implementation of the upcoming review of the salt law.

3.5 Vitamin B12

The serum data in women depicts the pre-COVID 19 deficiency of vitamin B12 is high at about 22% (National Micronutrient Survey 2011-12),(Table 3). The vitamin comes exclusively from animal foods which are consumed at low level. With the advent of the COVID 19 and the loss of employment, income 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.

4. Results

Examining the above contexts for the key micronutrient status in Bangladesh—such as, serum status, dietary micronutrient intake and the relative contribution of various sources, geological and programmatic issues, and the pandemic induced reversal of an otherwise improving dietary quality, the provisional risk - grade is assigned **arbitrarily** for the probable deterioration of the status of the selected micronutrients for the pandemic (Table 4).

Zinc, vitamin B12 and iodine are assigned with the “**High**” risk of regressing towards the reference time ⁽¹⁵⁾. Vitamin A is assessed to have the “**Moderate**” risk of falling back to the level of the reference time. 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 time.

Table 4: 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
Zinc	Pre-COVID 19: <ul style="list-style-type: none"> High existing serum deficiency coupled with sub-optimum dietary intake Overall low intake, high-plant & low-animal origin intake inversely affect serum status (Rahman 2016, Iqbal 2019) 	High*
	COVID 19 & aftermath: <ul style="list-style-type: none"> Loss of employment/income with increased food insecurity & poorer diversity of diet, low ASF Possible nullifying the gains in the quality of micronutrient intakes (e.g. ASF) 	
Iron	Pre-COVID 19: <ul style="list-style-type: none"> Predominantly low burden of ID determined by a fair-to-high amount of wholesome iron consumed through drinking groundwater 	Low†
	COVID 19 & aftermath: <ul style="list-style-type: none"> 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: <ul style="list-style-type: none"> 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 residents, urban new poor of big cities. 	High‡
Vitamin A	Pre-COVID 19 <ul style="list-style-type: none"> 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 (Rahman 2016) 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 (Mbuya 2020) 	Moderate§

	COVID 19 & aftermath <ul style="list-style-type: none"> ▪ 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. 	
Iodine	Pre-COVID 19 <ul style="list-style-type: none"> ▪ High subclinical deficiencies with no appreciable dietary sources ▪ Predominant supply is from iodized salt, suboptimum use of adequately iodized salt persistently (NMS 2011-12, MICS 2019, Knowles 2017) ▪ Poor content of iodine in open salt (Knowles 2018) ▪ Concern that the industrial salt might end up being the edible salt with retailers with uncertain/inadequate iodine level (OPM/IDS/GAIN 2020) COVID 19 & aftermath <ul style="list-style-type: none"> ▪ 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 low-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 enactment and enforcement of the upcoming comprehensive salt law. 	High ¶
Vitamin B12	Pre-COVID 19 <ul style="list-style-type: none"> ▪ High serum deficiency coupled with low animal-sourced food intakes COVID 19 & aftermath <ul style="list-style-type: none"> ▪ 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 underprivileged people. 	High ¶¶

*High risk for regressing towards the reference time (NMS 2011-12)

†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 (Rahman 2019, personal communication)

‡High risk for regressing towards the reference time (NMS 2011-12) where iron content is very low (<0.08 mg/L; personal communication) and/or the water is chemically treated; mostly applies to the underprivileged/slum population residing in the metropolitan cities

§Moderate risk for regressing towards the reference time (NMS 2011-12); and likely to remain a public health concern especially in children (subclinical retinol >10%) WHO

||High risk for regressing towards the reference time (NMS 2011-12)

¶High risk for regressing towards the reference time (NMS 2011-12)

5. 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 (Sandstrom 2001). Hence, its projection to a specified level is far from being straightforward. The assumptions behind the present projection might change over time, in the form of 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.

While the projection exercise was based on a plethora of objective perspectives, such as the preexisting serum/urine status, quantitative intakes-to-requirement gaps, segregation of bioavailable or poorly bioavailable sources, environmental and programmatic issues with impediments—the Government of Bangladesh has promptly embarked upon some macro-level initiatives to tackle the situation(BNNC 2020). The initiatives are as follows:

- a. To promote food security, an executive order has been issued for exploitation of all cultivable lands, providing fiscal-monetary sustenance to farmers
- b. To promote food supply to the poor, the government along with the private sector and civil society organizations, has embarked upon support programs, e.g. food and cash relief, open market sale of essential food items at subsidized prices, and extension of the safety net programs. Coverage of social protection has been planned to be expanded to include the ‘new poor’.
- c. The Bangladesh National Nutrition Council (BNNC) and the National Nutrition Services (NNS), and the National Technical Expert Committee developed a nutritionally rich food package to be used as emergency rations for COVID-19 affected populations.

Hence, 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 the many of them remained excluded (HIES 2017). Hence the benefits might not be reached to all who are in need the most.

The strength of the appraisal counts that it is founded on some key outcomes at the aftermath of COVID 19 which are actually measured in the country, e.g. loss of work/income, increased food insecurity, poor dietary diversity and food intake. The association of these outcomes and nutritional/micronutrient status is extensively proven globally. Further, the appraisal was done by examining the key objective contextual factors--pertaining to 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.

6. Conclusion

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 for the regress towards the reference period (NMS 2011-12). Vitamin A, poses a **“Moderate”** risk of sliding back to the reference time. 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 (NMS 2011-12) for most of the population of the country. However, the underprivileged population hard-hit by the financial strains and exposed to very low levels of groundwater iron are pitted to a **“High”** risk of the decline perhaps worse than the reference time. Appropriate mix of coordinated interventions need to be planned, customized and operationalized along with the strengthening and monitoring of the current interventions, e.g. fortification of edible oil with vitamin A and salt iodization with the process of enactment and enforcement of the proposed more comprehensive salt law. Effective measures are needed to better targeting the poor for the safety net programs. An emphasis is placed on enabling the improved access of animal sourced food especially for the underprivileged populations.

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Supplementary Table 1: A comparison of the selected micronutrient status of the NMS 2011-12 and the Jivita Cohorts Study (Personal Communication)

Micronutrient deficiency (%)	NMS 2011-12 (Children aged 6-59 mo)	NMS 2011-12 (Non-pregnant women 15-49 y)	NMS 2011-12 (Children aged 6-14 y)	Jivita 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

Supplementary Table 2: Escalating food prices (January-April 2020)*

Food items	Increase in the price (%)
Rice (all-varieties)	7- 46%
Pulses	24%
Broiler chicken	56%
Mutton, beef	3-4%

Oil, milk registered an increase in price

*Determining the impact of COVID 19 on nutrition (BNNC 2020)