ORIGINAL ARTICLE

Double fortified salt and deworming"- game changers in the battle against iodine and iron malnutrition in Indian school children

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Abstract

Background Controlling malnutrition among school children has been a priority issue of current nutrition strategies in India. However, meeting majority of the MDGs by controlling micronutrient deficiencies among school children demands attention and intense efforts by the country. Various state governments have implemented different strategies in school health programs, but the results are not very promising. Thus as an universal strategy, double fortified salt (DFS) can be implemented as a measure to combat deficiencies of two micronutrients. **Aims and Objective**s to assess impact of NIN-DFS supplementation on micronutrient status (iron and iodine) of rural school children with deworming and NHE. **Methods and materials** School children (N=947) (6-15 years) from rural villages of Vadodara, Gujarat were randomly selected and were assigned into 4 case control groups using DFS and deworming as intervention strategies. **Results** After 9 months of intervention, median UIC improved significantly (p<0.001) in both the groups and the prevalence of iodine deficiency decreased significantly (p<0.001). Mean Hb improved (+0.60 g/dl) significantly (p<0.001) among supplemented group (DFS+DW) compared to decrease (-0.54 g/dl) among control group (DW). IQ/cognition scores also improved significantly among experimental groups (p<0.01, Memory and draw-a-man test scores) compared to control groups. However, NHE provided to the parents of the school children, helped to meet major proportion of RDA of the children. The micronutrient status of the children was observed to improve significantly, who were benefited by multiple approaches. **Conclusion** DFS production and consumption should be promoted as universal strategy at policy level and multiple strategies should be used to benefit the targeted population in simple and most effective manner.

Key Words

Double fortified salt supplementation; iodine deficiency; iron deficiency; school children

Introduction

Iron is one of the most essential micronutrient at every stage of human life, other than iodine and Vitamin A. Almost one third of the world's population suffer iron deficiency anemia (IDA). India has its major share with high prevalence (70- 80%) of IDA in children (NFHS-III) [1]. Simultaneously iodine deficiency disorders (IDD) is estimated to affect 7.1 crore people in India while 20 crore are at risk. Anemia affects the oxygen carrying capacity of the cells reflected as lower levels of hemoglobin and thereby reduces the work capacity of the children. Iron deficiency along with iodine deficiency affects the developing brains, physical and mental growth of the children [2]. WHO (2001)[3] reported, multiple micronutrient deficiencies coexists in developing countries at a higher rate due to monotonous diets based on staple foods of low nutrient density. Typical Indian diets contain adequate amounts of iron, but the bioavailability of iron from rice and wheat, the staple cereals of Indians goes down, since absorption gets affected by phytates and other inhibiting factors. In addition to that, the intake of meat products which are rich in heme iron is low. The most vulnerable groups are Pregnant and lactating women, school children, young infants and adolescents.

Controlling malnutrition among school children has been a priority issue of current nutrition strategies in India. However, meeting majority of the MDGs by controlling micronutrient deficiencies among school children demands attention and intense efforts by the country. As effectively advocated, public health approaches towards the control and prevention of iron deficiency are the distribution of supplements of iron and fortification of foods with a suitable iron compound. Medical input of iron is recommended for a short-term measure for the correction of anemia, while fortified foods are used to improve the iron balance over a period of time and build up iron reserves. State Governments have initiated supplementation (Iron) under the National Program Policy. Sustainability is the key to success of supplementation strategy and it is more likely to be achieved if the supplement has a low cost, is simple to distribute, easy to administer and prevent deficiency [4]. It has to be efficacious enough for the school setups where the children have short and long term vacations coupled with high rate of absenteeism in rural areas. In this case daily or weekly iron supplementation as tablets may affect the compliance. Therefore, the results are not very promising due to variability in the compliance and gap between supply and distribution.

Hence, food fortification could be the practical approach to deliberately increase the intake of essential micronutrients, in order to improve the nutritional quality of the food supply and provide a public health benefit with minimal health risk (WHO-2004) [5]. India already has a program to supply adequate iodine through iodized salt. Hence, double fortification of salt with iron and iodine makes eminent sense [6]. In India, the efforts towards producing a stable formula containing iron first and later merging iodine and iron together were pioneered by Dr. Narsinga Rao in early 70s. As a sequel to the introduction of universal iodization of edible salt as a National Policy in the country, National Institute of Nutrition (NIN) evolved the concept of double-fortified salt (DFS) with iodine and iron for controlling the deficiencies of both these micronutrients in a single measure as “one intervention controlling two problems.”

Hence, looking into the scenario and demand of time NIN-DFS was chosen as an effective and feasible strategy to combat both deficiencies in children.

Aims & Objectives

- To assess the impact of DFS supplementation with and without deworming on iodine and hemoglobin status of the rural school children.
- To assess the impact on cognitive performance of the children

Material and Methods

Study Design: A longitudinal intervention study. **Study population:** Primary school children (6-15 years) were enrolled from the rural schools of Waghodia, in Vadodara district, Gujarat. At baseline four schools were selected purposively (based on the availability of iodized salt) where n=1184 children were enrolled at baseline, and n=947 could complete the study due to various reasons for drop out (frequent absenteeism, not willing to participate, missing data, parent’s withdrawal of consent to name a few). Two schools were experimental group (n=442) (IS availability >50%), who were given DFS as an intervention and the other two were control group (n=505) where the children were recommended to continue consuming iodized salt (IS) (IS availability >90%). Further using deworming as additional strategy, these groups were subdivided as two experimental -DFS+ DW (n=256), DFS (n=221) and two control- IS+DW (n=353) and IS (n=353) – groups. The study was carried out during March 2010-April 2011.

Data collection and supplementation: The children were explained the purpose of the study and the class teachers were involved for rapport build up with younger children (6-9 yrs). At baseline anthropometric (height and weight), urinary iodine excretion (UIE) and hemoglobin (Hb) measurements were recorded. Weight was taken with the help of digital bathroom scale with least count of 0.01 Kg. The bathroom scale was calibrated before use. Height was taken by fiber glass tape as that was the feasible method in the field level in rural area. Baseline data on IQ/Cognition through standard tests (Draw-a-man test [7], Visual Memory and Cancellation) was collected. DFS packets (1kg) were distributed among experimental group during first week of every month and average required quantity for the family could be derived within first two months. From the third month the children received adequate packets of salt to suffice their family intake. Albendazole 400 mg was given twice during the study period. The intervention period was 9 months, after which the post data collection for all groups repeating anthropometric measurements, UIE and Hb sample analysis and IQ/cognitive tests were carried out. All the groups were also provided NHE regarding the need and importance of iodine and iron nutrition in children.

Methods of estimation

Urine (10-50 ml) and blood samples (0.02 µl) were drawn from the subjects at the time of enrollment and at the end of supplementation period to assess their iodine (by UIE µg/L) and iron status (Hb g/dl); Urine samples were stored at 25 ^{0}C and 2 ml of toluene was added as preservative to each sample. Urinary iodine (UI) excretion was measured (at 405 nm) by modified simple microplate method [8] using ELIZA reader (Tecan Autria GMBH, Europe) at ICCIDD Laboratory, New Delhi. Blood samples were collected (dry blood spots) [9] for hemoglobin estimation using cyan met-hemoglobin method. The hemoglobin (Hb) measurements were performed on the samples within few hours of blood collection and were read on spectrophotometer (spectronic 20D) at 304 nm.

Definitions: IDA was defined using UNICEF/UNU/WHO (2001) [3] criteria for Hb concentration (g/dl) in children (≥11.5: Normal, 10.0-11.49 g/dl: Mild, 7.0-9.9 g/dl: Moderate and <7 g/dl: Severe).

ID was defined using WHO (2007) [10] criteria for UIE in children (≥100 µg/L: Normal, 50-99 µg/L: Mild, 20-49 µg/L: Moderate and ≤20 µg/L: Severe)

Statistical analysis : The data was processed, entered and analyzed in the Statistical Package for Social Sciences for windows version 15.00 (SPSS 15.0). Growth indices were analyzed in Epi-Info, Version 3.5.3. Simple Statistical analysis was performed using Chi-square (X2) when appropriate for categorical data. Results of anthropometry and hemoglobin were reported as mean (±sd). UI was reported as median. For comparing data between groups, paired't' test or Mann Whitney 'U' test, ANOVA or 'H' tests were used as appropriate. A two-tailed p value at <0.05 was considered statistically significant.

Ethical statement: The study approval was obtained from the ethical committee of the home institution ethical board in compliance with the guidelines issued by Indian council of Medical research (No. F. C. Sc FN ME70).

Consent: Written permissions from all the schools and district education officer were availed to carry out the work. All the children from 1st to 6th standard were enrolled for the study. Written consent from the parents of the children (in local language) and oral consent from the children was also availed.

Results

Baseline characteristics including gender distribution, age, height, weight and BMI have been described in the (Table 1). Mean age of the children was 9± 2 yrs.

After completion of study period, mean height of the children increased by 6.36 ±1.86 cm [122 (initial) - 128.42 (final)] and weight by 3.40 ± 1.80 kg [20.83 (initial) - 24.23(final)]. The highest increase was observed among DFS+DW compared to other groups. However, the difference was statistically non-significant (data not presented).

Impact on iron status

Overall initial mean hemoglobin of the children was 9.17±1.22 g/dl which decreased significantly (p<0.05) to 9.08 ± 0.88 g/dl towards the end. Hence, entire population fell under moderately anemic category (WHO 2001) [3] at both time points. Group wise distribution showed significant (p<0.001) increase (Mean: +0.42g/dl) in Hb concentration among experimental groups (DFS+DW and DFS) after 9 months of supplementation [8.67 (initial) – 9.09 (final)], however it decreased significantly (p<0.001) in control groups (-0.54 g/dl) (IS+DW and IS). DFS +DW showed (+0.60 g/dl) highly significant (p<0.001) rise in the hemoglobin concentration (Table 2).

Overall prevalence of anemia at baseline was 99%. There was a significant reduction in the prevalence of anemia (moderate + severe) among DFS+DW (6.3%) group compared to significant rise in control groups (p<0.001) at the end. However, DFS group showed non-significant rise in the prevalence rate (1.5%) on completion of the study (Table 3).

Impact on iodine status

On comparing median UI concentration at baseline, all the groups showed values above the cut-off for iodine deficiency (>100 µg/dl) [10] (Table 4). Sufficient iodine nutrition at baseline gave a clue to availability of iodized salt in the region. However, an action of two essential micronutrients through single vehicles was to be assessed as an objective of the study. Hence, continuing with the sufficient population, half of the children were provided replaced supply of iodized salt with DFS to assess the efficacy of iron and iodine together.

Overall median UI concentration (UIC) of the population was 145.91 µg/L at baseline, which increased significantly ($p<0.001$) to 204.03 µg/L towards the end. This suggests the increased iodine nutrition amongst the children. The rise in UIC was highly significant ($p<0.001$) in all groups at the end compared to baseline values (Table 4). Baseline prevalence of iodine insufficiency varied among all study groups and it was highest in DFS+DW group. However, the prevalence of iodine insufficiency in all groups also decreased significantly ($p<0.01$) towards the end followed by the rise in UIC (µg/L). It was observed to be highest among DFS+DW group compared to other study groups (Table 5).

Impact on cognition:

Draw- a Man Test Overall increase in IQ scores in DFS+DW group was observed to be highest compared to rest of the groups ($p<0.01$) (Table 6). The difference was observed to be significant compared to DFS group ($p<0.001$) and IS+DW ($p<0.01$) (Post hoc test and independent't'). However, DFS group showed a non-significant difference compared to both control groups (IS and IS+DW). This suggests that, DFS along with deworming showed better impact on IQ (data not presented).

Visual Memory Test DFS group showed a highest increase compared to other groups and there was a significant difference between all four groups at baseline and at the end of the study period ($p<0.001$) (Table 6). When compared for the differences in mean values between groups, significant difference was observed between DFS v/s IS ($p<0.01$) and IS+DW ($p<0.05$). However, DFS+DW also showed a significant difference compared to IS group ($p<0.01$) and non-significant difference compared to IS+DW group. Comparisons within experimental groups (DFS v/s DFS+DW) and control groups (IS v/s IS+DW) showed a non-significant difference (data not presented).

Clerical Test:

DFS+DW showed a highest rise compared to rest of the groups (Table 6). However, when compared for within groups and between groups comparisons revealed non-significant difference. This also proved a positive impact of both DFS and deworming on the concentration level of the children (data not presented)

Discussion

Evidence based studies have reported that, physical growth and cognitive development in children are faster during early years of life, and that by the age of four years, 50% of the adult intellectual capacity has been attained and before thirteen years, 92% of adult intellectual capacity is attained[11]. However, it is affected significantly due to micronutrient deficiencies, especially iron and iodine. Anemia affects mental and physical performances of the school children irrespective of their genders. School age is a period of rapid growth, where iron requirement for both girls and boys increase. The minimum daily dietary iron requirements are 12-15 mg/day for this age group [4]. However, it is surprising and moreover disappointing to know that in rural settings the children cannot meet the RDA for iron despite fully fledged MDM programs and government schemes for IFA supplementation at regular intervals. This is majorly due to lack of compliance and unawareness regarding the beneficial effects. In such a situation blanket coverage for DFS supplementation could provide partial support to the daily dietary need for iron along with meeting complete requirement of iodine. In our study, DFS could bring remarkable impact on hemoglobin status of the experimental group compared to control group. This could have been due to sustained iron release from DFS and thus the children could achieve their daily RDA for iron along with iodine. At baseline, 17-47% of the experimental group children could meet RDA for Iron, which increased to 35- 120% ($p<0.001$) towards the end due to addition of DFS in their daily diet. On the other hand, control group did not show remarkable rise in iron intake respite giving regular NHE sessions. Hence, DFS was proven to be the best cost effective measure for improving iron intake and thereby Hb concentrations in the supplemented children.

Salt is a daily diet necessity for all and it was supplemented for entire family so none of the experimental group consumed their homemade meals without DFS. Incorporating DFS to Mid-Day Meal (MDM) recipes in experimental schools also proved to be beneficial. Indeed it was interesting to note that the percent of anemic children in both the groups did not change since it was very high (98-99%), but the percent distribution under anemia classification showed a positive shift towards mild category from moderate and none of the children remained severely deficient among experimental group. However, in control group there was a significant rise in moderately anemic subjects who shifted from mild category towards the end. These findings are in compliance with earlier reports [12] for an eight months DFS trial in rural Ghana, the prevalence of anemia in supplemented children decreased by 21.7% (p<0.02) and no change in control group was observed. These transitions were negative in control group since almost 20% of the children suffered moderate anemia at the end who were mildly anemic at baseline. Similar pattern was also observed [13] in a UNICEF study in Delhi among the children aged 6-15 years for anemia who belonged to the orphanages, where population was wheat based.

In our study, Iron content of DFS (10 mg/day = 70 mg/7 days) is comparable with the study on impact assessment of IFA /iron tablets supplementation once weekly or fortified foods supplementation to the school age children. The improvement in iron status amongst our study subjects could have been due to small but daily supply of iron through the daily diet of the children compared to the tablets or supplements which are not the part of routine food items. A study supporting our findings [14] revealed that, the increase in anemics was twice than the borderline-anemics regardless of iron doses. The Malaysian adolescent girls in the study were supplemented with different doses of iron-folic acid supplements. (Either 60 mg or 120 mg Iron + 3.5 mg Folic acid once a week) for 22 weeks. With this regards, it can be stated for our study findings that, DFS also could bring better impact in the children, since majority of them were anemic. The cohort school study by NIN 2000 clearly demonstrated an improvement in hemoglobin concentration in mild-moderate anemic than in those with normal levels.

Impact on iodine status

DFS being an adequate source of iodine due to optimal fortification (40 ppm) likewise IS, showed a significant (p<0.001) positive shift in the percentage of UI sufficient children. The experimental population, where the availability of iodized salt was lower than the control group and thus chosen for DFS supplementation groups, showed an increase in UI sufficiency to > 80%. However, in control group where the availability of iodized salt was almost 100% but due to improper dietary - cooking - storage practices of iodized salt, they were not able to achieve 100% iodine sufficiency. After NHE as an effective intervention, control group also showed remarkable improvement in UI levels with sufficiency at >90%. A study conducted in south India [15], amongst school children revealed a significant (p<0.001) increase in median UI at the end of 10 months of supplementation compared to the baseline values. These values were 182, 143 and 133 µg/L in IS, DFS1 and DFS2 groups respectively at baseline and they increased to 355, 166 and 252 µg/L towards the end. There are more supporting evidences available on the impact of DFS or IS supplementation resulting in increased UI concentration in both the groups [16-20].

Impact on cognition:

A number of studies in school children showed improvement in IQ and cognition tests scores when their hemoglobin concentration was improved with the alleviation of anemia [21-24]. Most of the studies on effect of iron supplementation (iron alone or iron-folic acid) compared to control groups, generally showed a significant improvement on cognitive function or educational achievement amongst children [25-26].

In our study, when DFS was supplemented for the period of 9 months, it resulted in increased scores of all the three tests (DMT, VMT and CT) in all the study groups. Rise in mean scores of each group was observed to be highest amongst experimental groups. The increase was significantly high (p<0.001) in DFS+DW group for DMT test (IQ test) compared to rest of the groups. This in turn suggested the role of increased efficiency of iodine in the presence of iron due to its role in the action of thyroperoxidise enzyme and in the absence of worm infestation due to their irradiation by deworming. However, in the absence of iron supplementation, IS and IS+DW groups could not show better improvement compared to experimental groups. Hence, an increase in the IQ scores of each group could be a result of the familiarity, but still varied on their iron and iodine status at the end. The mean IQ scores improvement has motivated our efforts by categorizing experimental groups into “Average” performance category compared to “Below average” scores for the entire population. However, control groups could not make that standard up (based on the IQ classification by Phatak P 2002).

In the letter cancellation test/ Clerical test which is a measure of attention and concentration, our study population demonstrated that the increment in mean scores was observed to be significant in all the groups. The improvement in CT scores was observed to be higher amongst E+DW group compared to the rest groups, though non-significant. This in turn suggests contributing role of iron released from DFS in absence of worm infection amongst children.

Conclusion

The study population was iodine insufficient, so efforts should be targeted in achieving iodine sufficiency. The hemoglobin status of the population calls for an immediate action to be improved since most of the children are anemic >90%. Among children from rural settings, there are limited dietary sources for iron due to limited purchase power of the families and ignorance as major causes. Hence, DFS should be included in the daily diet of the families to meet partial RDA for iron and complete RDA for iodine at an economic cost and to have a sustained liberation of iron from the salt in the gut.

DFS+DW has been proven to be the best strategy to bring about reduction in the prevalence of anemia within a desired period of study tenure. However, DFS supplementation alone also was proven to be the better strategy compared to the control groups, which maintained the status and resisted the drastic reduction in the hemoglobin status during the growth spurt of the children at preadolescent and adolescent age. Our study findings have also been supported by the conclusions discussed in the NIN reports, indicating the efficacy of NIN-DFS in reducing anemia prevalence significantly ($p<0.001$) by improving hemoglobin concentration amongst anemic children [27].

Recommendation

Our study recommends the use of multiple approaches to combat micronutrient deficiencies as an initiative and support strategies from all stake holders and the government for a permanent solution in the battle against malnutrition.

Limitation of the study

Data on bioavailability and absorption of iron from the preparations where DFS was used were not conducted due to limited funding.

Relevance of the study

This study contributes to the information on better efficacy of DFS supplementation and deworming as effective tools to combat micronutrient deficiencies than their individual performance in a semi-rural setting.

Authors Contribution

KJ: conceptualized, designed and carried out this study as a part of her PhD programme. SN: guided her for the same.

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Tables

TABLE 1 BASELINE CHARACTERISTICS

Characteristics	DFS+DW (n=239)	DFS (n=203)	IS+DW (n=214)	IS (n=291)
Male	129 (54%)	108 (53%)	133 (62%)	146 (50%)
Female	110 (46%)	95 (47%)	81 (38%)	145 (50%)
Age (yrs)	9.47± 2.22	8.89±2.30	8.86±2.30	9.42±2.30
Height (cm)	121.22 ±12.28	120.13 ±12.49	122.52 ±12.03	123.75±12.67
Weight (kg)	20.08±5.09	19.93± 5.49	21.42±6.19	21.64±6.47
BMI (kg/m^2)	13.43±1.22	13.55±1.52	13.94±1.75	13.81±1.97

TABLE 2 MEAN HEMOGLOBIN CONCENTRATION OF EACH GROUP BEFORE AND AFTER INTERVENTION

	DFS+DW	DFS	IS+DW	IS	'F' Value
Initial	8.46± 1.24	8.91±1.19	9.69±1.05	9.51±1.01	**62.55*** **
Final	9.06±0.86	9.12±0.88	9.15±0.94	9.01±0.87	**1.24^{NS}**
Difference	0.60±1.09	0.21±1.04	-0.54±0.85	-0.56±0.90	**83.91*** **
Paired 't'	**8.47*** **	**2.92** **	**9.23*** **	**10.49*** **	

**p<0.01, ***p<0.001

TABLE 3 CHANGE IN PREVALENCE OF ANEMIA IN ALL GROUPS

Study Group	Total N	Percent prevalence of moderate + severe anemia					Chi square (A v/s B)
		n	Initial % (A)	n	Final % (B)	% difference	
DFS+DW	239	217	90.8	202	84.5	- 6.3	**60.69*** **
DFS	203	164	80.8	167	82.3	+1.5	**0.711**^{NS}
IS+DW	214	130	60.7	178	83.2	+22.5	**30.97*** **
IS	291	190	65.3	251	86.3	+21.0	**46.74*** **

***p<0.001

TABLE 4 MEDIAN UIC (µG/L) OF EACH GROUP BEFORE AND AFTER INTERVENTION

	DFS+DW	DFS	IS+DW	IS	'H' Value
Initial	118.92	148.62	156.28	158.83	**35.51*** **
Final	165.30	201.44	261.54	227.60	**61.87*** **
Difference	41.08	45.62	103.10	43.98	**23.63*** **
'Z' test	**5.91*** **	**4.61*** **	**8.16*** **	**5.96*** **	

***p<0.001

TABLE 5CHANGE IN THE PREVALENCE OF IODINE DEFICIENCY IN ALL GROUPS

Study Group	Total N	Percent prevalence of iodine deficiency based on UIE					Chi square (A v/s B)
		n	Initial % (A)	n	Final % (B)	% difference	
DFS+DW	239	96	40.2	38	15.9	- 24.3	**7.79** **
DFS	203	67	33.0	25	12.3	- 20.3	**12.38*** **
IS+DW	214	58	27.1	14	6.5	- 20.6	**3.97***
IS	291	64	22.0	24	8.2	- 13.8	**8.66** **

*p<0.05, **p<0.01, ***p<0.001

TABLE 6 MEAN IQ AND COGNITION SCORE COMPARISON BETWEEN ALL GROUPS

	Study Groups (N=700)				'F' value
	DFS+DW (n=195)	DFS (n=169)	IS+DW (n=154)	IS (n=182)	
Draw-a-man Test (DMT)					
Initial	81.46±18.53	94.25±19.08	85.55 ±21.1	81.65 ± 17.9	**17.16*** **
Final	89.14±22.26	96.90±19.75	87.51 ±19.0	86.34 ± 20.1	**9.24*** **
Difference	7.68 ± 16.91	2.65 ± 12.12	1.95 ± 18.30	4.69 ± 15.56	**4.69** **
Paired 't'	**6.34*** **	**2.84** **	**1.33**^{NS}	**4.07*** **	
Visual Memory Test (VMT)					
Initial	0.52 ± 0.25	0.37 ± 0.22	0.41 ± 0.27	0.50 ± 0.29	**14.35*** **
Final	0.63 ± 0.25	0.51 ± 0.26	0.48 ± 0.28	0.53 ± 0.27	**11.04*** **
Difference	0.11 ± 0.23	0.15 ± 0.19	0.07 ± 0.22	0.03 ± 0.26	**8.31*** **
Paired 't'	**6.58*** **	**9.89*** **	**3.81*** **	**1.77**^{NS}	
Clerical Test (CT)					
Initial	0.69 ± 0.24	0.75 ± 0.25	0.76 ± 0.24	0.75 ± 0.28	**2.74***
Final	0.79 ± 0.21	0.83 ± 0.19	0.83 ± 0.19	0.82 ± 0.21	**1.57** ^{NS}
Difference	0.10 ± 0.25	0.08 ± 0.22	0.07 ± 0.25	0.07 ± 0.26	**0.66** ^{NS}
Paired 't'	**5.93*** **	**4.89*** **	**3.96*** **	**3.74*** **	

*p<0.05, **p<0.01, ***p<0.001