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School Food Fortification Improves Nutrition Status of Students from Poor Migrant

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Abstract

To observe the effect of food fortification including multinutrient fortified rice, iron fortified soy sauce and VA fortified cooking oil on school children of rural-urban migratory families. The school children in a boarding school for children of migrated families in suburb Beijing city were selected as volunteer subjects and the school cafeteria were supplied with iron fortified soy sauce, multinutrient fortified rice and VA fortified cooking oil for 10 month. Dietary survey and nutrition measurement were conducted before and after 10-month intervention with fortified foods. Hb, SF, SI, sTfR, serum Zinc and serum VA were measured with blood samples. VB1 and VB2 were measured with urine samples. The results showed that the daily intakes of the fortified micronutrients reached the requirements of Chinese AI or RNI through the application of fortified foods. Haemoglobin, serum zinc, VA, urine VB1 and urine VB2 levels were significantly increased in 10 months intervention compared with the baseline while sTfR level was significantly lower than that of the baseline. Anemia prevalence was decreased from 14.1% to 2.5% and the rates of deficiencies and inadequacies of iron, zinc, VA, VB1 and VB2 were significantly reduced. The observation revealed that food fortification could be an effective and feasible approach for lowering the micronutrient deficiencies of school children of migrated people who are considered one of the most vulnerable populations, but randomized controlled trials are needed to accumulate further evidences.

Keywords: School students; Iron fortified soy sauce; Fortified rice; Vitamin A fortified cooking oil; Migrant population; Poor families; Nutrition intervention

Introduction

Internal migration has transited more than 200 million populations from rural area to urban in recent decades in China. Most of the migration uses to be poor farmers and they expected to have higher income after migrated to urban, but because of the job uncertainty and less skill of new works, their living conditions may become even worse. They are described as inferior in urban and considered the nutrition vulnerable population. The children from poor migrated families (CPMF), also called floating people have attracted more social attention as an extremely social vulnerable group. Some studies have reported that students in schools of CPMF showed lower health and nutrition status compared with students in public school [1]. The prevalence of micronutrient deficiency and anemia were even higher in schools of CPMF compared with those who are still in rural, but the problem has been somehow neglected [2]. Food fortification is a cost-benefit approach for prevention of micronutrient deficiency and sufficient experiences have been accumulated from both developed and developing countries. There have been some reports for food fortification projects showed the health effects in both students and other groups of population in China and the related fortified foods including multimicronutrients enriched wheat flour and rice, VA enriched cooking oil and iron enriched soy sauce [3]. Food fortification is considered a feasible and sustainable method in promoting student nutrition status in CPMF schools, but there still lack of practices and evidences. This study was designed to observe the change on micronutrients status of students intervened for 10 months by iron fortified soy sauce, multinutrients fortified rice and VA fortified cooking oil in a CPMF schools.

Method

Subjects and sampling

A CPMF school named Dandelion School located in Daxing county, a region in suburb of Beijing, where was one of gregation region of the migrant population. Dandelion is the only school within the region that recruits only CPMF as students and the students are not charged for any tuition fees, in addition, the school receives 600 RMB (approximately 95 USD) for a year to supply meals and dorms, but it is also free to the extremely poor students. There were about 640 students in the school aged from 11 to 16 years old and 56% percent of the students boarded in the school from Monday morning to Friday evening. Those who lived nearby would go home every day accounted for 44% percent of the total, but they have their breakfast and lunch in the school. The school cafeteria supplies three meal every day except weekend and the cost of meal for one day is less than 6.3 RMB or 1 USD because both the school donors and lower income of floating parents could not afford more. Rice is main staple food and vegetable soups were supplied and there is one or two eggs each week per student and one meat meal each two weeks supplied. Only grade 1 and 2 students account 2 third of the total were asked for the study since the grade 3 students would take high school entrance examinations. The protocol of the study was fully informed to the parents of the students as well as students and teachers. The parents and school principal signed support agreements for using fortified foods in the school cafeteria and agreed the students to join in the measurement and blood sampling. All the students and their parents agreed for supply of fortified food.

All the students were voluntarily screened with medical examination questionnaires before the fortified food supplied and the students with medical records showing chronical diseases related with heart, stomach and intestine, respiratory organs, blood etc. would not be suggested for sampling. If Hb could be less than 90 g/L, the students would be suggested to go hospital for clinic cure. Students and parents again voluntarily made they are decision for participated sampling or not, thus the study assumed a convenient sample method. All the 358 boarding students in the school were sampled, but 38 students among them were rejected for the final analysis because 24 students absented to the school and not consumed the fortified foods for more than 10 days for helping family business. 11 students moved with their parent to other places and 3 students refused to blood sampling because of pain. Totally 320 students with 192 males and 128 females participated diet survey and the blood sampling, among them 178 students with 113 males and 65 females finished urine sampling for the measurement in 10 months intervention period.

Fortified foods

Iron fortified soy sauce, multinutrients fortified rice and VA fortified cooking oil were donated by the producers of Haitian fermentation company, DSM China Company and China Oil & Foodstuffs Corporation (COFCO) respectively. The companies produced those foods according to the national standards and the qualities required by the study organizer were guaranteed by producer's internal quality assurance system and measurements. Fortified foods were supplied to both the school cafeteria and to the families of the boarding students since the students should have meals in their families during weekends, holidays and vacations. Students have consumed fortified food for 10 months and after the study fortified foods continuously supplied to the school for 2 years as a donation without any study and observation in terms of ethnical consideration. The nutrients fortified in the products are listed in **table 1**. The protocol was evaluated and approved by the "Ethnical Committee for Human Trials" of Institute of Nutrition and Food Safety, China CDC.

Carrier	Fortified Nutrient	Fortificant	Fortified Amount	Daily Consumption
Soy Sauce	Iron	NaFeEDTA	26 mg/100ml	15 ml/ person/day
Cooking Oil	VA	Retinol acetate	8000 μg/kg	25 g/ person/day
Rice	Iron	Ferric pyrophosphate	24 mg/kg	0.15-0.31 kg/ person/day
	VB1	Thiamine hydrochloride	3.5 mg/kg	
	VB2	Riboflavin	3.5 mg/kg	
	Zinc	Zinc dioxide	25 mg/kg	
	Folic acid	Folic acid	2 mg/kg	
	Nicotinic acid	Nicotinamide	40 mg/kg	
	β-carotene	β-carotene	3 mg/kg	

Table 1: Nutrients composition of fortified food

Measurement

Diet survey included two parts. One part designed to measure the diet in school cafeteria was conducted with 5-day recording on food quantities consumed and numbers of students who had meals in the school cafeteria. Another part was designed to measure the diet in home during the weekend and 24 hrs record method was used for the measurement [4]. The nutrients intakes were calculated by the food weight measured and Chinese food composition table that gives the nutrients contents of foods.

Before the intervention and 10 months after the intervention, finger-tip blood samples were collected for the tests of Haemoglobin (Hb) and venous blood samples were collected to test Serum Iron (SI), Serum Ferritin (SF), Serum Transferrin Receptor (sTfR), Serum Zinc and Serum Vitamin A. Urine samples were collected for the test of urine Vitamin B1 (VB1) and Vitamin B2 (VB2).

Before 7 o'clock in the morning, 5mL fasting venous blood of the subjects were taken and centrifuged at 3,000 rpm for 15 min after 20 minutes static laid. The upper part of the serum was transferred to the serum tube and stored in the freezer at -80℃ for the further measurement in laboratory.

Four-hr load urine test was used where the subjects were asked to urinate after breakfast before orally taking 5 mg Thiamine and 5 mg Riboflavin with 300 ml warm water. 4 hr after, urines were collected with a 400 ml plastic bottles and the samples were homogenated and volume measured. 10 ml of each urine sample was transferred to the brown glass for further measurement of thiamine and riboflavin concentration in the same days in China CDC's laboratory according to the referenced methods [5].

HemoCue method was used to measure Hb [6], immunoturbidimetry used for SF [7], Double-antibody Sandwich ELISA for sTfR [8], Flame Atomic Absorption Spectrometer (FAAS) for SI [9], immune transmission turbidity for C-reactive protein, high performance liquid chromatography (HPLC) for serum VA [10], FASS for serum zinc and fluorimetry for thiamine and riboflavin [11].

Data analysis

SPSS 18.0 software was used for the data analysis. Levene's test for homogeneity of variance was conducted and if the arrangements were not normal, log-transformation or other methods should be used to make it normal. Paried samples t-test (two tailed) was performed to compare the differences between baseline and after 10 months intervention of Hb, SF, sTfR, SI, serum A, serum zinc, urine VB1 and urine VB2. Chi-square test was used to compare the changes of the rates of anemia and deficiency rates or inadequate rates of iron, VA, zinc, VB1 and VB2.

Results

Diet Supply and Nutrients Intakes

The ages of students measured were arranged from 11-16 and the total number was 320 with male 192 and female 128. 89.1% mothers and 78.5% fathers had rather low education level and only undergone middle school or lower education. Most of the parents engaged physical strength work which is considered not a stable occupation (**Table 2**).

	Description
Total Student Numbers	320
Male	192
Female	128
Ages Of Students	13.6 ± 1.2 yrs, arranged from 11-16 yrs
Ages Of Parents	39.3 ± 3.6 yrs, arranged from 35-42 yrs

Education Level Of Parents	
Mother	
Primary School or Below	47.8%
Middle School	41.3%
High School	9.3%
College or Higher	1.6%
Father	
Primary School or Below	20.4%
Middle School	1 58.1%
High School	18.2%
College or Higher	3.3%;
Occupation of Parents	
Labors	
Father	46.3%
Mother	38.9%
Peddler	
Father	43.3%
Mother	34.8%
Unemployment	
Father	4.2%
Mother	21.7%
Others	
Father	6.2%
Mother	4.6%

Table 2: The general information of the students measured

The dietary survey showed that the inadequate intakes of both macronutrients and micronutrients were rather the normal problem in the students in Dandelion school (**Table 3**).

The nutrients intakes estimated through daily consumed food quantity of surveyed students were inadequate compared with their Chinese Recommended Nutrient Intakes (RNI) or Adequate Intakes (AI) except VC. There were no RNI or AI for 4 nutrients such as carbohydrate and dietary fibre etc,. As the diet pattern was remain unchanged during the intervention period, the calculation was conducted based on the quantities of daily consumed foods to show the intakes of iron, zinc, VA, B1, B2 that fortified in soy sauce, rice and cooking oil had increased averagely more than the RNI/AI. It suggested the fortified foods improved some of micronutrient intake level up to the needed.

		Male		**Female**	
Nutrient		11y~	14y~	11y~	14y~
		(n=83)	(n=109)	(n=50)	(n=78)
Nutrient not fortified					
Energy (kcal)	Means ± SD	2110.4 ± 122.4	2372.5 ± 225.8	1893.7 ± 84.5	2104.2 ± 142.9
	RNI	2400	2900	2200	2400
	Mean/RNI (%)	87.9	81.8	86.0	87.7
Protein (g)	Means ± SD	56.3 ± 4.1	63.2 ± 7.2	50.5 ± 2.8	55.9 ± 4.4
	RNI	75	85	75	80
	Mean/RNI (%)	75.1	74.4	67.3	70.0
Carbohydrate (g)	Means ± SD	370.4 ± 26.2	427.3 ± 49.5	323.4 ± 17.9	370.3 ± 30.4
Fat (g)	Means ± SD	20.0 ± 1.2	20.7 ± 2.0	18.9 ± 0.8	20.0 ± 1.4
Edible fiber(g)	Means ± SD	52.9 ± 1.5g	53.8 ± 1.9	51.7 ± 1.2	52.4 ± 1.8
VC (mg)	Means ± SD	111.5 ± 10.0	114.8 ± 12.3	106.8 ± 10.4	107.6 ± 10.7
	RNI	90.0	100.0	90.0	100.0
	Mean/RNI (%)	123.9	114.8	118.7	107.6
	Means ± SD	301.3 ± 25.8	323.6 ± 29.6	285.4 ± 20.4	300.3 ± 28.4
Ca (mg)	AI	1000.0	1000.0	1000.0	1000.0

	Mean/AI (%)	30.1	32.4	28.5	30.0
	Means ± SD	830.4 ± 66.7	942.4 ± 116.8	739.8 ± 48.5	825.7 ± 72.9
P (mg)	AI	1000.0	1000.0	1000.0	1000.0
	Mean/AI (%)	83.0	94.2	74.0	82.6
	Means ± SD	1552.0 ± 110.6	1672.5 ± 136.2	1426.3 ± 92.5	1526.1 ± 124.0
K (mg)	AI	1500.0	2000.0	1500.0	2000.0
	Mean/AI (%)	103.5	83.6	95.1	76.3
	Means ± SD	285.2 ± 19.8	318.4 ± 31.8	258.0 ± 14.5	283.7 ± 23.1
Mg (mg)	AI	350.0	350.0	350.0	350.0
	Mean/AI (%)	81.5	91.0	73.7	81.1
	Means ± SD	22.0 ± 2.0	24.8 ± 3.4	19.7 ± 1.4	21.8 ± 2.2
Se (μg)	RNI	45.0	50.0	45.0	50.0
	Mean/RNI (%)	48.9	49.6	43.8	43.6
	Means ± SD	1.8 ± 0.1	2.1 ± 0.3	1.6 ± 0.1	1.8 ± 0.2
Cu (mg)	AI	1.8	2.0	1.8	2.0
	Mean/AI (%)	102.2	105.5	90.0	91.5
Mn (mg)	Means ± SD	6.5 ± 0.5	7.6 ± 1.0	5.7 ± 0.4	6.5 ± 0.6
Nutrients fortified					
VA (μgRE), fortified as β-carotene	Means ± SD	313.2 ± 44.8	325.5 ± 45.5	306.9 ± 46.2	308.2 ± 42.2
	RNI	700	800	700	700
	Mean/RNI (%)	45.0	40.7	43.8	44.0
	Mean/RNI (%) after intervention	105.2	96.7	101.4	104.5
VB1 (mg)	Means ± SD	0.98 ± 0.10	1.11 ± 0.18	0.86 ± 0.08	0.97 ± 0.10
	RNI	1.2	1.5	1.2	1.2
	Mean/RNI (%)	81.7	74.0	71.7	80.8
	Mean/RNI (%) after intervention	151.7	141.7	130.0	150.8
VB2 (mg)	Means ± SD	0.57 ± 0.05	0.59 ± 0.04	0.47 ± 0.02	0.51 ± 0.04
	RNI	1.2	1.5	1.2	1.2
	Mean/RNI (%)	47.5	39.3	39.2	42.5
	Mean/RNI (%) after intervention	112.5	105.7	97.5	112.5
Iorn (mg)	Means ± SD	18.3 ± 1.3	20.5 ± 2.2	16.4 ± 0.9	18.2 ± 1.4
	AI	16	20	18	25
	Mean/AI (%)	114.3	102.5	91.1	72.8
	Mean/AI (%) after intervention	174.6	156.8	139.6	111.3
Znic (mg)	Means ± SD	9.3 ± 0.7	10.7 ± 1.0	8.3 ± 0.4	9.2 ± 0.8
	RNI	18.0	19.0	15.0	15.5

	Mean/RNI (%)	51.7	56.3	55.3	59.4
	Mean/RNI (%) after intervention	112.5	105.7	97.5	112.5

Table 3: Nutrient intakes per day per student and the percentage to RNI/AI before and the percentage of fortified micronutrients to RNI/AI after food fortification intervention

Iron status and anemia

CRP is an acute-phase protein and its level rises in response to inflammation. SF level increases abnormally if inflammation happens in the body. CRP was used as index to judge inflammation and if CRP>5 mg/L, SF value should be adjusted to be SF+26%SF [12]. In this observation, results of CRP from all blood samples were lower than 5 mg/L which suggested that CRP were within the normal arrangement.

SF levels increased 7.1 ± 9.7 μg/L (P<0.01) and SI 0.08 ± 0.07 mg/L (P<0.05), while sTfR levels decreased 4.5 ± 11.3 nmol/ L in male students after 10 month intervention (**Table 4**).

		Male	**t**	**Female**	**t**	**Total**	**t**
items	Intervention months	n=192	P	n=128	P	n=320	P
Hb(g/L)	Baseline	135.3 ± 12.4		131.6 ± 12.3		133.8 ± 12.5	
	10-mon-intervention	141.3 ± 8.9	0.000	138.0 ± 8.7	0.000	140.0 ± 8.9	0.000
SF(μg/L)	Baseline	45.5 ± 26.7		38.4 ± 31.4		42.7 ± 28.8	
	10-mon-intervention	52.6 ± 21.6	0.000	49.2 ± 26.0	0.000	51.2 ± 23.5	0.000
sTfR(nmol/L)	Baseline	22.7 ± 8.9		23.7 ± 8.2		23.1 ± 8.6	
	10-mon-intervention	20.0 ± 6.5	0.000	18.0 ± 5.3	0.000	19.2 ± 6.1	0.000
SI(mg/L)	Baseline	0.91 ± 0.23		0.89 ± 0.20		0.90 ± 0.22	
	10-mon-intervention	0.99 ± 0.21	0.000	0.96 ± 0.18	0.006	0.98 ± 0.20	0.000

Table 4: Results of Hb, SF, sTfR and SI after nutrition supplementation (± s) Note: P<0.05 and P<0.01: significant differences or high significant differences in comparison between 10-mon-intervention and the baseline. SF level <15μg/L is defined as iron deficiency, but SF should be adjusted if CPR>5 mg/L.

The female students showed a similar trend. The results showed iron status for students of both male and female was improved. Hb levels increased 6.0 ± 7.5 g/L and 6.4 ± 7.1 g/L respectively for male and female after 10 month intervention. The changes were significant.

Iron deficiency rate decreased from 25.6% to 2.5% and anemia prevalence from 14.1% to 2.5% through 10-month intervention (**Table 5**).

		Male n=192			**Female n=128**			**Total n=320**		
		N	**%**	**P**	**N**	**%**	**P**	**N**	**%**	**P**
Anemia prevalence	Baseline	25	13.6		22	18.0		45	14.1	
	10-mon-intervention	4	2.2	0.000	4	3.3	0.000	8	2.5	0.000
Iron deficiency prevalence	Baseline	37	20.1		45	36.9		82	25.6	
	10-mon-intervention	4	2.2	0.000	4	3.3	0.000	8	2.5	0.000

Table 5: The change of anemia and iron deficiency prevalence after nutrition intervention (%) Note: P<0.05 and P<0.01: significant differences or high significant differences in comparison between 10-mon-intervention and the baseline. Anemia is defined by Hb levels for different groups. The criteria for anemia and iron deficiency are: 5 to-11 year olds <115g/L; 12-14 year olds <120g/L; females 15 years old and above <120g/L; males 15 years old and above <130g/L.

Female students showed higher iron deficiency and anemia rates in the baseline suvery, 18.0% and 36.9% respectively, than that of male students, 13.6% and 20.1%, therefore, more decrease was found in female students in terms of iron deficiency and anemia.

Changes of serum zinc, serum retinal, VB1 and VB2 after intervention with fortified foods

Levels of serum zinc and serum retinol significantly increased 0.14 ± 0.15 mg/L and 9.0 ± 8.4 µg/dL respectively (**Table 6**).

	Serum Zinc (mg/L)	P	Serum retinol (µg/dL)	P	Urine VB1 (µg/dL)	P	Urine VB2 (µg/dL)	P
	n=320		n=320		n=178		n=178	
Baseline	0.78 ± 0.25		38.4 ± 11.8		283.2 ± 156.0		1218 ± 595	
10-mon-intervention	0.92 ± 0.23	0.000	47.3 ± 14.2	0.000	379.8 ± 143.4	0.000	1440 ± 476	0.000

Table 6: Levels of serum zinc, serum retinol, urine VB1, and urine VB2 before and after intervention (± s) **Note**: P<0.05 and P<0.01: significant differences or high significant differences in comparison between 10-mon-intervention and baseline.

The urine VB1 and VB2 increased significantly from 283.2 ± 156.0 µg/dL to 379.8 ± 143.4 µg/dL and 1218 ± 595 µg/dL to 1440 ± 476 µg/dL measured by load-4-hr test. The results suggested that the nutrients status of zinc, retinol, VB1 and VB2 have been improved by food fortification. Data in **table 7** showed a decline of zinc deficiency from 34.5% to 14.1% in male students and decline from 36.6% to 12.9% in female students.

	N	%	P	n	%	P	n	%	P
Zinc	Male (n=192)			Female (n=128)			Total (n=320)		
Baseline	66	34.5		47	36.6		113	35.3	
10-mon-intervention	27	14.1	0.000	16	12.9	0.000	43	13.4	0.000
retinol	Male (n=192)			Female (n=128)			Total (n=320)		
Baseline Deficiency	16	8.1		10	7.6		26	8.1	
Marginal deficiency	34	17.9		17	13.0		51	15.9	
10-mon-intervention Deficiency	3	1.7	0.000	1	1.1	0.000	4	1.2	0.000
Marginal deficiency	12	6.4	0.000	8	6.5	0.000	20	6.3	0.000
VB1	Male (n=113)			Female (n=65)			Total (n=178)		
Baseline Deficiency	11	9.7		7	10.8		18	10.1	
inadequate	33	29.2		23	35.4		56	31.45	
10-mon-intervention deficiency	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000
inadequate	6	5.3	0.000	2	3.1	0.000	8	4.5	0.000
VB2	Male (n=113)			Female (n=65)			Total (n=178)		
Baseline Deficiency	11	9.7		2	3.1		13	7.3	
inadequate	23	20.6		17	26.2		40	22.5	
10-mon-intervention deficiency	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000

inadeaute	10	8.9	0.000	4	6.2	0.000	14	7.9	0.000

Table 7: Change of deficiency rates of zinc, VA, VB1 and VB2 after intervention Note: P<0.05 and P<0.01: significant differences or high significant differences in comparison between 10-mon-intervention and the baseline. 1) serum zinc <0.75 mg/L defined as deficiency; 2) serum retinol level of [20,30)/ μg/dL is defined as marginal deficiency, [10,20) as deficiency and <10 as severe deficiency; 3) urine VB1 of [100,200) μg/dL is defined as inadequate and 100 as deficiency; 4) urine VB2 of [400, 800) μg/dL is defined inadequate and <400 as deficiency.

The average decrease of zinc deficiency was from 35.3% to 13.4% in all the measured students. VA deficiency decreased from 8.1% to 1.2% and marginal VA deficiency from 15.9% to 6.3%. None of the students showed severe VA deficiency before and after the intervention.

Total VB1 deficiency declined from 41.6% to 4.5% in total subjects with deficiency 9.7% to 0% and inadequate 29.2% to 5.3% in male students before and after intervention, while female students 10.8% to 0% and 35.4% to 3.1% respectively. The VB2 deficiency showed a similar trend with VB1.

Discussion

The migrated people used to be the poor population engaged in the farm work, but has been stimulated to move to the urban regions. The migration is developed in recent 3 decades with a complex social, economic and policy reasons, but it obviously induces some new social issues including social inequity and health problems since the number of the migrants is estimated over 200 millions in China. Children including those still staying the home village with the grandparents (left-behind-children) and those come together with the parents in floating life are all suffering from less enough care in term of health and nutrition. Studies on anemia and iron deficiency as well as other micronutrients have accumulated sufficient data with reliable biochemistry indicators for left-behind-children [13-16] , but here seems few studies conducted to observe the nutrition status of the CPMF as a special groups in China. The baseline survey in this observation showed deficiency of nutrients status in CPMF in Dandelion school which is induced by less diversity of foods because of low income of parents and the deficiency can have serious impact on the health status for the students not only at present time, but also for the future [17,18].

The measurement results of blood and urine samples revealed the increases of levels of iron, retinol, zinc, VB1 and VB2. The deficiency rates also significantly dropped to lower levels. The results of this intervention were supported with other intervention programmes. Supply with iron fortified soy sauce and multinutrients fortified wheat flour could increase the levels of those fortified micronutrients in students and decrease the deficiency rates reported by the previous observations in Chinese schools [19,20]. National Food Authority of the Philippines in 1998 distributed fortified rice in two provinces as part of school breakfast feeding programme and Hb level of students after six months of intervention rose from 10.8 to 11.7 and SF rose from 8.64 to 21.25 [21,22]. A Thailand observation reported improvement on nutrition status of 5.5~13.4 years old children after 31-week intervention with zinc, iodine, iron and VA fortified condiments [23]. Deborah et al provided soft drink fortified with iron, VA, iodine, zinc, VC, Riboflavin , Folic Acid, VB12, VB6 and VE to 6 to 11 year old students in Tanzania and the results showed significant increase of iron status and physical performance of the students and reduced anemia and VA deficiency rates [24].

There was no control group in this study to give more confirmation on the results. The control group was considered in the study design, but since Dandeline School is the only large CPMF volunteer school for the study and all other CPMF schools in the region was either too small or lack of school licence, the study team had to work without a control group. This observation showed a significantly improvement of nutrition status of the CPMF students through fortified foods including iron fortified soy sauce, VA fortified cooking oil and fortified rice. The total anemia rates among students dropped from 14.1% to 2.5%. 10-mon-intervention measurements indicated improvement levels of Hb, SI, SF, Serum Zinc, VA, Urine VB1 and Urine V B2 and reduction of sTfR level. Micronutrient deficiency or inadequacy rates suggested a positive impact of fortified foods on micronutrient deficiency in students in Dandelion school. We considered that fortified foods might have positive effects on the students of CPMF who were generally at risk of micronutrients deficiency, although more strictly designed studies should be conducted to further confirm the results. The listed in tables also suggested the impacts of fortied foods to different genders, but the numbers of subgroups of male and female were not meet the sampling requirement, therefore, this reveals also needs to be confirmed by further studies.

According to WHO guideline, micronutrient food fortification is a cost-benefit method for the public nutrition improvement especially in developing countries [25]. The feasibility of food fortification in CPMF schools relies on the cost of fortificants and manufacture as well as its affordability and acceptability. The cost of foods for students in CPMF schools uses to be about 150 RMB (23.8 USD) per person per month (about 22 days) from the example of Dandelion school. According to our estimation, the extra fee was only 0.04-0.07 RMB (0.006-0.011 USD) per student per day by replacing none fortified with three fortified foods and it is affordable by even poorest families or by the compensation of donation in CPMF schools. Food fortification in CPMF schools was accepted by both Dandelion school caffiteria and students as the fortified food is noticeably no different with those none fortified. One considered problem may be from distribution capacity since the CPMF schools are often located in poor transportation regions which are not covered by the few producers presently producing those fortified foods. If the problem is not resolved by a market mechanism, the cost for the distribution will be increased dramatically in terms of coverage of CPMF schools in whole country. Fortified foods producers and market distributors may play very important role to make those fortified foods reachable to the CPMF schools and government support through invest or policy establishment should also be crucial to scale up the school fortification for a better nutrition of migrant students.

Large population based randomized controlled researches are needed for accumulating more information on the effectiveness of fortified foods on CPMF school students.

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Conclusion

Iron fortified soy sauce, multinutrients fortified rice and VA fortified cooking oil introduced into CPMF schools could improve the micronutrients intakes of VA, VB1, VB2, folic acid, niacinic acid and zinc from inadequate to adequate levels. Indicated by the biochemistry parameters suggested that the food fortification should positively affect on the micronutrients status of the CPMF students, but a randomized controlled trial should be needed for further confirmation of the nutrition effects in CPMF schools in China.

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Conflict of Interest

The authors declare no conflict of interest in this study.

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