Policy Forum

The Role of Nutrition Education in the Promotion of Iron-Fortified Soy Sauce in China*

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Iron deficiency anemia (IDA) is one of the most important nutrition issues in China[1-2]. Data from the 2002 National Nutrition and Health Survey showed that the average anemia prevalence in China was 20.1% and the prevalence in women of child-bearing age and of children in some poor regions reached more than 50%; it has been estimated that more than 200 million Chinese people are suffering from anemia[3-4]. Anemia significantly affects physical and mental development in children[5], decreases productivity in adults, and reduces immune function among the population at large, which leads to a lower health status and limits social development[6]. Iron deficiency has proven to be the major cause of anemia in China, based on intervention studies using iron-fortified foods[7-8]. Food fortification is recognized as an economic, effective, and feasible way for micronutrient nutrition improvement and vast experience has been accumulated in the control and prevention of iron deficiency and IDA through food fortification[9-10]. As early as 2000, a large-scale double-blind controlled population-based intervention study in Bijie County, Guizhou Province, China, showed that the provision of iron-fortified (NaFeEDTA) soy sauce to individual families was effective for IDA prevention and control[11]. Since 2004, with the administrative support from the Ministry of Health of China, and financial support from the Global Alliance for Improved Nutrition (GAIN), NaFeEDTA-fortified soy sauce (180-260 mg Fe/L soy sauce, as NaFeEDTA) was made available in six provinces and municipalities (i.e., Jiangsu, Guizhou, Hebei, Guangdong, Jilin, and Beijing), with subsequent expected achievements in IDA control[12].

In most countries, the application of fortified foods occurs through a mandatory approach to achieve the highest population coverage, which is the key to the success of a national fortification program. However, the regulatory environment in China makes it difficult to promulgate a government regulation on mandatory iron fortification of soy sauce. Alternatively, the market-driven approach guided by the government is acknowledged to be a feasible way to promote iron-fortified soy sauce for the control of IDA. There is no previous experience to learn from or successful examples to follow in this field; thus, China will be a pioneer among large countries by using a social marketing approach to develop a market-driven mechanism to conduct a national nutrition improvement program[13]. The key to the success of this approach is to increase the awareness of the general consumer and change their behavior in regard to iron-fortified soy sauce. The study selected the city of Jinhua, Zhejiang Province, as a pilot site to conduct nutrition education based on a market-driven approach guided by the government, in order to develop an effective and feasible model for the promotion of iron-fortified soy sauce in China.

Study Setting and Population Two studies have shown positive effects of an iron-fortified soy sauce intervention on the hemoglobin levels and anemia rates of study subjects[11,14]. Based on these results, the anemia rate was used to evaluate the project's effects. Cost benefit was also analyzed. Nutrition education about IDA and iron-fortified soy sauce was conducted jointly by the Food Fortification Office of the Chinese Center for Disease Control and Prevention, the Zhejiang Provincial Center for Disease Control and Prevention, and local (district and county) government health departments.

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Wucheng District (urban) and Dongyang County (rural) of the city of Jinhua were selected as intervention sites to promote the use of iron-fortified soy sauce. Both Wucheng District and Dongyang County are coastal areas in the eastern part of China, which have 760,000 and 820,000 residents, respectively. According to a survey conducted in 2009, the average IDA prevalence in males and females was 9.0% and 18.5% respectively in Wucheng, and 15.4% and 27.2% respectively in Dongyang[15-16]. During the project, there was sufficient iron-fortified soy sauce in markets. The iron-fortified soy sauce available in the study sites was manufactured according to national standards[17] by the local Zhejiang Huyang Fermentation Company and the Guangdong Haitian Fermentation Company of Gongdong Province. The concentration of iron in the iron-fortified soy sauce was 26 mg (200 mg NaFeEDTA) per 100 mL soy sauce, which supplied approximately 2-3 mg iron per day per person.

The information distributed through nutrition education included basic knowledge about iron deficiency and IDA, the current status and health risks of iron deficiency and IDA, and iron-fortified soy sauce as an effective and simple way to prevent iron deficiency and IDA. Specific nutrition education activities included an on-site launch conference with the participation of professionals from this project, national and local health departments, local governments, and the media, with the aim of (1) obtaining support from, and full participation of, all stakeholders at a local level; (2) mobilizing media participation; and (3) building acceptance of regular public science education (Table 1). After each launch conference, the designated iron-fortified soy sauce companies provided iron-fortified soy sauce to the local food stores and supermarkets for voluntary purchasing. The price of the iron-fortified soy sauce was the same or 2%-4% higher than the non-fortified soy sauce.

Outcome Assessment Women aged from 20 to 60 years old were selected as study subjects due to their high risk for IDA out of the 265,000 and 286,000 targeted women in Wucheng and Dongyang respectively[18]. The assumption and rationale for sample size estimation[19] were:

Design effect: 2

No response rate: 10%

N: sample size

$\bar{P}=(P_1+P_2)/2$ (1)

P_1: 30%, the baseline anemia prevalence

P_2: 21%, estimated by a 30% decrease of anemia prevalence

Z_α: $Z_{0.05/2}=1.96$

Z_β: $Z_{0.2}=0.84$

$$N=\frac{[Z_\alpha\sqrt{2\bar{P}(1-\bar{P})}+Z_\beta\sqrt{P_1(1-P_1)+P_2(1-P_2)}]^2}{(P_1-P_2)^2} \quad (2)$$

Based on the estimated sample size, 805 non-pregnant women were randomly selected for the baseline survey. Simple random sampling was used in the project. Of these subjects, 400 were urban residents and 405 were rural residents. If a person did not agree to participate in this project, the person with the nearest number was chosen.

Table 1. Types of Nutrition Education Activities

Activities	Quantity	Population Reached (individual)	Activities	Quantity	Population Reached (individual)
Wall poster	400 pc	20,000	Mass signature	1 time	80
Banners	14 pc	1,000	Public square education	3 times	400
Posters	590 pc	1,500	School activity	1 time	500
Brochures	4,600 pc	15,000	Moving board	8 times	4,000
News paper	5 times	50,000	Professional training	4 times	300
TV news	2 times	40,000	Community nutrition knowledge competition	1 time	200
TV-health talk	1 time	20,000	Market survey	6 times	600
Website promotion	2 times	10,000	Mid term evaluation	30 person times	30
Expert consultation	3 times	500	On-site promotion	1 time	100

Note. pc is piece.

After one year of intervention, 832 women were randomly selected: 415 (49.9%) were urban residents and 417 (50.1%) were rural residents. An additional 27 subjects were included in order to compensate for about 3% invalid questionnaires in the baseline survey.

The ethics committee of the Institute for Nutrition and Food Safety approved the projects. All of the subjects were fully informed and consent forms were signed and collected.

Knowledge, Attitude, and Practice Questionnaire Survey The Knowledge, Attitude, and Practice (KAP) questionnaire was designed by the Food Fortification Office of the Chinese Center for Disease Control and Prevention, based on the general KAP questionnaire used in health education, which has been subjected to expert consultation and pilot testing[20]. The questionnaire included knowledge of iron nutrition and iron-fortified soy sauce as well as soy sauce purchasing (i.e., the behavior). The same questionnaire was used at the baseline survey and at the end of the year. The questionnaire was administered face to face by health professionals at local Centers for Disease Control and Prevention. The interviewers were trained by Chinese Center for Disease Control and Prevention before the field work. The results of the questionnaire survey were analyzed for knowledge of iron nutrition and purchasing behavior. During the baseline survey, 805 questionnaires were administered; of these, 400 were urban and 405 were rural, and altogether 94.7% were valid. At the end of the intervention, 832 questionnaires were administered; 415 were urban and 417 were rural, and altogether 96.7% were valid.

Blood Hemoglobin Measurement Left-hand middle-finger blood was tested for hemoglobin content using the HemoCue portable spectrophotometer method (Angelholm, Sweden)[12]. Anemia was diagnosed according to the World Health Organization criteria[21]; that is, for non-pregnant adult women, the cut-off point for anemia was 120 g Hb/L.

Cost-Benefit Analysis It has been hypothesized that the main economic loss from anemia is the loss of productivity. The estimation of productivity loss was based on the major hypothetical variables and the following formula was used in the calculation[22]:

Total productivity loss due to anemia = productivity loss due to anemia in people who perform physical work and productivity loss due to anemia in people who perform heavy physical work. The practical formula was:

Anemia prevalence change in workers × number of workers × employment rate × light physical workers (%) × average net income of local residents × benefit loss (5%) + anemia prevalence change in workers × number of workers × employment rate × heavy physical workers (%) × average net income of local residents × benefit loss (12%). (3)

Quality Control A working manual was prepared for the training of the field survey health professionals, including a one day baseline survey practice (pilot survey). The completed questionnaires were checked for missing and/or wrong information. Corrections were made on-site. A unified code system was developed and the data entered were subjected to validity and logic checks.

A control curette was used to calibrate the portable HemoCue. The measurement was performed when the temperature was in the range of 15-30 °C, as required by the equipment.

Data Analysis The database was developed using EpiData 3.0 (The EpiData Association, Odense, Denmark,) after double data entry followed by checking and cleaning. Statistical analysis of the data was conducted using the SPSS version 17.0 (SPSS, Inc., Chicago, IL, USA) software. The method used included the chi-square test and $P<0.05$ was considered statistically significant[23].

Sociodemographic Characteristics The baseline survey and the survey after one year revealed that the sociodemographic characteristics were significantly different between rural subjects and urban subjects (Table 2).

Knowledge of Iron Nutrition and IDA The baseline survey revealed that knowledge of iron deficiency and IDA was much poorer in rural subjects (Table 3). Among the rural subjects surveyed, 82% did not know about the syndromes caused by IDA, 78% had no idea about population groups at high risk of iron deficiency, and 88% were not aware of the causes of iron deficiency, while the percentages in urban subjects were 21%, 16%, and 17% respectively. After one year of intervention, the knowledge of iron nutrition and IDA was significantly improved in both urban and rural residents. The improvement was more significant in the Dongyang (rural) subjects than in the Wucheng (urban) subjects (Table 3).

Knowledge of Iron-Fortified Soy Sauce and Purchasing Behavior The knowledge and purchasing rate of iron-fortified soy sauce were

significantly (P<0.01) improved in both urban and rural sites (Table 4) after one year of intervention. The percentage of subjects who knew that iron-fortified soy sauce was available in the local stores was 13.2% and 25.2% in rural and urban subjects respectively, but only 5.3% and 6.3% of the total subjects had purchased iron-fortified soy sauce. At the baseline survey, 2.1% of urban subjects had consumed iron-fortified soy sauce, but no rural subjects had consumed it.

Table 2. Distribution of the Subjects' Sociodemographic Characteristics

Questionnaire Items	Baseline			After		
	Dongyang (rural) *n*	Wucheng (urban) *n*	$P^{\#}$	Dongyang (rural) *n*	Wucheng (urban) *n*	$P^{\#}$
Age			>0.05			>0.05
20-	105	100		206	199	
40-	270	269		173	188	
60-	30	48		21	28	
Education			>0.05			>0.05
illiteracy	20	32		19	13	
Under Junior	358	342		189	212	
High school or technical secondary school	22	32		113	103	
College degree and above	6	11		78	87	
Type of work			>0.05			>0.05
Soy sauce sales staff	2	1		5	3	
Technician	3	6		23	30	
Worker	63	52		167	181	
Office Clerk	14	20		47	36	
Manager	0	2		9	15	
Public servant	2	3		20	9	
Service employees	50	38		19	30	
Individual proprietor	17	27		23	19	
Teacher	2	4		13	11	
Freelance	6	2		23	21	
Doctor/Nurse	2	5		9	12	
Retirement/ Unemployed	12	30		27	38	
Farmer	232	226		13	9	
Family income (one year)			>0.05			>0.05
≤20,000	132	56		23	95	
20,000≥50,000	132	203		184	174	
50,000-100,000	30	103		147	130	
≥100,000	4	55		46	14	

Note. $^{\#}$Comparison between baseline and after one year.

Blood Hemoglobin Level After one year of intervention, anemia prevalence was significantly (P<0.05) reduced in subjects in both urban and rural sites. The reduction rate was 32.3% in urban subjects and 30.5% in rural subjects, with an average of 31.2% (Table 5).

Table 3. Changes of Iron Nutrition Knowledge After Nutrition Education

Questionnaire Items	Dongyang (rural)			Wucheng (urban)			P^*	
	Baseline %	After %	$P^{\#}$	Baseline %	After%	$P^{\#}$	Baseline	After
Knows that iron deficiency can lead to anemia	13.2	37.2	<0.001	76.2	78.2	>0.05	<0.05	<0.05
Knows that iron deficiency anemia could cause following symptoms								
Pale in face	7.3	37.9	<0.001	62.6	54.1	<0.05	<0.05	<0.05
Weak	11.0	35.6	<0.001	50.9	46.4	>0.05	<0.05	<0.05
Fatigue	6.8	32.6	<0.001	53.4	54.6	>0.05	<0.05	<0.05
Feel cold	1.0	18.8	<0.001	24.6	26.7	>0.05	<0.05	<0.05
Easy to catch cold	3.7	17.6	<0.001	54.8	46.8	<0.05	<0.05	<0.05
Do not know	82.2	31.8	<0.001	20.6	12.6	<0.01	<0.05	<0.05
Knows about iron deficiency vulnerable population								
Infants	3.1	14.0	<0.001	30.9	31.3	>0.05	<0.05	<0.05
Children	11.5	25.7	<0.001	54.6	51.5	>0.05	<0.05	<0.05
Adolescents	0.5	5.1	<0.01	19.2	12.1	<0.05	<0.05	<0.05
Women	4.7	48.6	<0.001	55.7	54.1	>0.05	<0.05	>0.05
Elderly	9.9	26.0	<0.001	55.3	56.1	>0.05	<0.05	<0.05
Do not know	78.5	32.1	<0.001	16.3	10.7	<0.05	<0.05	<0.05
Knows about the cause of iron deficiency								
Loss blood	5.8	32.1	<0.001	45.6	42.2	>0.05	<0.05	<0.05
Diseases	3.7	22.4	<0.001	34.2	23.5	<0.01	<0.05	>0.05
Under nutrition	7.3	45.1	<0.001	76.2	72.8	>0.05	<0.05	<0.05
Do not know	88.0	40.5	<0.001	17.4	14.1	>0.05	<0.05	<0.05

Note. $^{\#}$Comparison between baseline and after one year nutrition education for the same site. *Comparison between two sites in baseline and after one year on nutrition education.

Table 4. Changes of Awareness of Iron-Fortified Soy Sauce After Nutrition Education

Survey Items	Dongyang (rural)			Wucheng (urban)		
	Baseline %	After %	P	Baseline %	After %	P
Have seen iron fortified soy sauce in stores	0.5	13.2	<0.01	4.6	25.2	<0.01
Have bought and used iron fortified soy sauce	0.0	5.3	<0.01	2.1	6.3	<0.01

***Note*.** Comparison between baseline and after one year nutrition education for the same site.

Table 5. Changes of Anemia Prevalence After Nutrition Education

Areas	Baseline (N)	After (N)	Prevalence Reduction Rate	P
Dongyang (rural)	24.9% (101/405)	17.3% (72/415)	30.5%	<0.05
Wucheng (urban)	36.8% (147/400)	24.9% (104/417)	32.3%	<0.05

***Note*.** Comparison between baseline and after one year nutrition education for the same site.

Cost of Nutrition Education The total cost of the nutrition education intervention including the launch conferences and activities for establishing partnerships with local government, iron-fortified soy sauce manufactures, suppliers, and stores; the education material development and distribution; the training of health professionals; and the local manpower, local facilities, and travel expenses was 300,800 RMB (47,670 USD). Of the total cost, the expenses for rural and urban activities were 135,400 RMB (21,458 USD) and 165,400 RMB (26,212 USD), respectively. The GAIN project funded 100,400 RMB (15,911 USD) for the two sites: 45,200 RMB (7,163 USD) for the rural site and 55,200 RMB (8,748 USD) for the urban site. The remaining costs were covered by the local government and Centers for Disease Control and Prevention.

Cost and Benefit Ratio The baseline anemia rate in women was estimated to be 30.8%; after one year of the intervention, the anemia rate was reduced to 21.2% and the reduction rate was 31.2%. The benefit resulting from this reduction of anemia rate was estimated to be 6.2 million RMB in Dongyang (rural) and 18.7 million RMB in Wucheng (urban). If extrapolated to the whole of the Zhejiang Province, the benefit was 117.0 million RMB. Therefore, the cost-benefit ratio of this intervention study was 1:46 for Dongyang (rural), 1:113 for Wucheng (urban), and 1:121 for Zhejiang Province as a whole (Table 6).

In this study, Jinhua residents' awareness of the health effects of IDA and the benefits of iron-fortified soy sauce was significantly improved after one year of nutrition education; this awareness led to behavior change (i.e., increased use of iron-fortified soy sauce) and, finally, to the significant reduction of IDA in local residents. The 1:121 cost-benefit ratio estimated for the whole of Zhejiang Province is consistent with our previous study [24].

Several interesting findings of this study were noted. First, after the nutrition education intervention, the improvement in knowledge of iron deficiency and iron-fortified soy sauce was more significant in rural (Dongyang County) residents than in urban (Wucheng District) residents, which suggests that health education would be more effective in less educated populations. This implies that different education strategies should be applied in urban and rural populations in future promotion activities. Second, although the awareness and purchasing rate of iron-fortified soy sauce was statistically significantly improved after one year of intervention, the overall knowledge level and proportion of residents regularly using iron-fortified soy sauce remained rather low, as compared with our previous studies[25], which implies that much more needs to be done for the promotion of iron-fortified soy sauce in China. Third, although the results of the cost-benefit analysis in this study are high and consistent with our previous studies conducted in other countries[26-27], the study methods need further improvement in order to be specifically used for evaluating the effectiveness of food fortification programs[28].

Table 6. Reduction of Productivity Loss by Anemia Control in Adult Women (20-60 years)

Variables	Dongyang (rural)	Wucheng (urban)	Zhejiang Province
Population (2011, ×1000)	286	265	17,560
Anemia rate (%, 2011)	24.9	36.8	30.8
Anemia rate (%, 2012)	17.3	24.9	21.2[1]
Cost (RMB)	135,400	165,400	9,640,000
Employ rate (%, all sectors)[2]	46.5	46.5	46.5
Ratio of labor *vs.* total workers[2]	60.4	60.4	60.4
Ratio of heavy labor *vs.* total workers[2]	18.1	12	15.1
Productivity loss in labor workers (%)	5	5	5
Productivity loss in heavy labor workers (%)	12	12	12
Per capita annual net income (RMB)[2]	11,877	28,593	30,971
Benefit from reduction of productivity loss (millions, RMB)	6.2	18.7	117
Cost and benefit ratio for nutrition education	1:46	1:113	1:121

Note. [1]: estimated from IDA decrease observed in Wucheng district and Dongyang county; [2]: data from Zhejiang Bureau of Statistics website refers to[12].

The moderate improvement of knowledge and increased use of iron-fortified soy sauce resulting from the nutrition education intervention may not be the only cause of the significant (30%) reduction in the anemia rate in the local residents. Other factors, such as dietary change and a healthy lifestyle due to economic development and urbanization, may also be important factors leading to overall nutrition improvement, including the increase of hemoglobin levels. In addition, the major cost of public nutrition education programs is labor, which is still relatively low at the small and middle size city and county level. This is also illustrated in the significantly lower cost (135,400 RMB) of nutrition education in rural than in urban (165,400 RMB) areas. All of these factors may explain the high cost and benefit ratio (Table 5) in this study.

Soy sauce, a widely used condiment, was first developed as a carrier for food fortification in China. There is no well-established promotion model and experience that could be used today for our reference. Based on the specific regulatory environment in China, it is necessary to develop a market-driven promotion approach for popularizing iron-fortified soy sauce. Our previous studies and this study show that nutrition education is the critical component of promotion and, if conducted properly, it could be effective in improving awareness and changing behavior. However, it would be a long-term process and needs joint efforts between government, industry, public health professionals, and the media.

In conclusion, this study has made some progress in using a nutrition education intervention as the major tool for the promotion of iron-fortified soy sauce. However, more studies should be conducted in different geographical areas in China with different ethnic groups, dietary habits, and education levels, in order to develop a comprehensive nutrition education model for the successful promotion of iron-fortified soy sauce in China.

Study Limitations There are some limitations in this study. First, the sample size was not sufficient to eliminate the effect of the country. The sample size will be increased in the next study. Second, nutrition education directly contributed to the improvement of knowledge about IDA and purchasing iron-fortified soy sauce, and further indirectly affected the level of anemia. How much the decrease in anemia is due to the increased knowledge rate and purchasing rate of iron-fortified soy sauce will be explored in the future.

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