The use of common salt (sodium chloride) fortified with iron to control anaemia: results of a preliminary study

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1. Iron-deficiency anaemia continues to be a major public health problem in all developing countries. Fortification of commonly consumed food items has been suggested as an effective method of preventing anaemia. Common salt (sodium chloride) has been identified as a suitable vehicle to be fortified with Fe in India.

2. Common salt was fortified with ferric orthophosphate (3500 mg/kg) and sodium hydrogen sulphate (5000 mg/kg) to provide an additional 1 mg elemental Fe/g common salt consumed.

3. After ascertaining the acceptability of the fortified salt with respect to its colour, taste and bioavailability a pilot feeding trial was conducted among residential schoolchildren in Hyderabad. Feeding of the fortified salt for a period of 1 year resulted in a significant increase in the haemoglobin level of these children. There was also a significant reduction in the prevalence of anaemia among children given the fortified salt.

4. Before the same fortified salt is recommended as a public health measure to prevent Fe-deficiency anaemia among our population it is necessary that further large-scale community trials with this fortified salt are carried out particularly among the rural population.

Iron-deficiency anaemia continues to be a major public health problem in many developing countries including India. Results of previous surveys conducted in several parts of the world have indicated that the prevalence of anaemia ranges from 10% in adult men to 80% in pregnant women (WHO, 1968; Cook *et al.* 1971; Aung-Than-Batu *et al.* 1972; Yusufji *et al.* 1973; Murugan, 1974; WHO, 1975). However, a recent survey conducted by this Institute in Indian rural areas has indicated a high prevalence of anaemia even among adult men (National Institute of Nutrition, 1978). A public health programme to control anaemia in pregnant women and preschool children through supplementation of iron and folic acid tablets has been initiated in our country. Although no systematic evaluation has so far been done, it appears to have met with little success due to several operational reasons (Nutrition Society of India, 1973).

Fortification of food with Fe has been suggested as an effective method for the prevention of anaemia (WHO, 1972). Several foods such as cereals, fish sauce and sugar have been used as the vehicle (Elwood *et al.* 1968; Garby & Arekul, 1974; Viteri *et al.* 1975). More recently common salt (sodium chloride) has been considered to be a suitable vehicle for Fe in India. Ferric orthophosphate (3500 mg/kg) along with sodium hydrogen sulphate (5000 mg/kg) has been found to be satisfactory (Narasinga Rao & Vijayasarathy, 1975). The bioavailability of Fe from this fortified salt when added to the diet was essentially similar to that from ferrous sulphate. Bioavailability did not alter on storage under hot humid conditions.

The fortified salt provides 1 mg of elemental Fe/g and at the estimated salt intake of 15 g/d per head (Pasricha, 1966) an additional 15 mg elemental Fe/d would be available.

The absorption of Fe from cereal-based diets of the type habitually consumed in India varies between 0·03 and 0·05 (Hallberg *et al.* 1974 and Narasinga Rao, 1978). Indian diets contain approximately 20–25 mg Fe/d and this together with fortified salt should meet the daily Fe requirement (1–1·5 mg) of a normal adult man. Fe absorption would be higher in women and anaemic subjects who need higher amounts (Narasinga Rao, 1978).

The fortified salt was found to be acceptable with respect to its colour and taste when incorporated into diets cooked by traditional methods. However, before fortified salt can be recommended for prevention of anaemia on a public health scale, its effectiveness has to be established by community trials. A pilot study was therefore undertaken to assess the effect of feeding Fe-fortified salt on the haemoglobin status of residential urban schoolchildren in Hyderabad.

MATERIALS AND METHODS

A total of 1080 boys and 565 girls in the age-range 5–15 years were registered for this study. These children were inmates of four residential schools in Hyderabad, two of them being boys' schools and the other two girls' schools. In the case of boys' schools one was a 'certified school' for reforming juvenile criminals and the other was an orphanage. The socio-economic background of the inmates of both these schools was similar. The 'certified school' was chosen as experimental and the orphanage as the control school. In the case of girls' schools one was a 'certified school' and the other was a residential school. The inmates of the residential school came from families with a slightly better socio-economic background. The residential school was chosen as experimental and the 'certified school' as control.

Of these children 222 boys and 161 girls in the experimental schools and ninety-two boys and seventy-one girls in the control schools were followed for 1 year. Ninety-seven boys in the experimental school and fifty-four in the control school were followed up for a further period of 6 months.

The inmates of the school were not allowed to leave the school premises except with special permission. Thus all food eaten by the children came from the community kitchen run by the authorities of the school. There was therefore little scope for children to consume food from outside. Each school had a medical officer who attended to all minor ailments. It was ensured with their co-operation that no Fe or any other haematinics were given to these children during the study period.

Base-line values for haemoglobin (Hb) and packed cell volume (PCV) were obtained and the schools were supplied with unfortified crushed common salt for a period of 1 month to get the children and the cooks used to the salt. Fe-fortified salt was then supplied to the experimental schools while the use of unfortified salt was continued in the control schools. It was also ensured that no salt other than that supplied by the Institute was used during the entire period of the study. Hb and PCV estimations were carried out at 6, 12 and 18 months after the introduction of fortified salt. Blood samples were collected during the morning.

Hb estimation

Hb was estimated by the cyanmethaemoglobin method using the filter-paper technique (National Institute of Nutrition, 1974). In the first 500 subjects, estimations were done on duplicate samples to determine the extent of variation. Thereafter, every 10th sample was analysed in duplicate as a check on the method. The mean (±SE) duplicate variation was found to be 3·5±0·013 g/l.

PCV estimation

PCV was estimated by the micro-haematocrit technique (Dacie & Lewis, 1975).

Dietary Fe estimation

The Fe content of the meals was determined three times during the study period of 1 year on five duplicate meal samples, collected from each school. Fe was estimated in these diets after wet digestion using the thiocyanate method (Oser, 1965).

Absorption of Fe

Absorption of Fe from the fortified salt was determined in five children by the double-isotope technique using the whole-body counter (Narasinga Rao & Vijayasarathy, 1975).

RESULTS AND DISCUSSION

Analysis of the results revealed that the mean ($\pm$SE) Hb level at the time of the base-line survey was 121 ± 1.0 g/l in the experimental boys and 123 ± 1.9 g/l in the control boys. These values were not statistically different from each other. For the purpose of this study, children with Hb values below 120 g/l were considered anaemic (WHO, 1968). Based on this criteria the extent of anaemia was also found to be similar in both these groups of boys, prevalence rates of anaemia being 53.7% in the experimental and 42.7% in the control.

In the case of girls, however, the initial Hb level in the experimental group (137 ± 1.5 g/l) was higher than that in the control group (126 ± 1.8 g/l). The prevalence rates of anaemia were also different in the two schools (15.5% for the experimental school, 33.8% for the control school). Because of certain logistic problems, the children (girls) matched for Hb level could not be used, and appropriate statistical methods were therefore used for comparing the values.

Results were analysed as follows: (1) comparison of mean Hb and PCV values at different periods of feeding the fortified salt by using the paired *t* test for differences between initial and final values and Student's *t* test for differences between experimental and control groups (Snedecor & Cochran, 1967); (2) comparison of the increase in Hb between experimental and control groups at different levels of initial Hb values by Student's *t* test (Snedecor & Cochran, 1967); (3) comparison of the prevalence of anaemia before and 1 year after the introduction of the fortified salt by using the test of proportions (Snedecor & Cochran, 1967) and (4) comparison of frequency distributions of Hb before and after the introduction of fortified salt.

When analysed using the previously mentioned methods, it was observed that at 6 months after the introduction of fortified salt, there was no significant change in the haematological status. However, at 12 months and 18 months in both boys and girls Hb levels had significantly increased in the experimental groups. In boys of the control group there was a small decrease. The increase in the experimental group was found to be statistically significant, when compared to that of the control group. There was however no difference between the increase observed at 12 months as compared to the increase at 18 months (Table 1).

To overcome the difficulty of non-comparability of initial Hb values in girls they were classified according to their initial Hb level and comparisons made between experimental and control children within each Hb group. A similar analysis was carried out for the boys. The results of these analyses are shown in Table 2. The increase in Hb depended on the initial Hb level, and at each Hb level the response in the experimental group was significantly higher than that in the control group. It was also found that the reduction in Hb occurred only in children whose Hb level was over 120 g/l, the maximum reduction being observed in children whose Hb levels were 140 g/l or more.

Prevalence rates of anaemia were compared before and 1 year after the introduction of fortified salt. The results are presented in Table 3. In both boys and girls the reduction in the prevalence of anaemia was significantly higher ($P < 0.001$ and $P < 0.01$) in the experimental group. In the control group there was no statistically significant change in prevalence rates. The frequency distribution of Hb values before and after the introduction of salt is shown in Fig. 1. A shift to the right was seen in the case of the experimental group as opposed to the control group, which remained essentially unaltered. Analysis of the PCV values yielded similar results.

Table 1. *Effect of administration of fortified common salt (sodium chloride) on mean haemoglobin (Hb) levels (g/l) in residential Indian schoolchildren*

(Mean values with their standard errors)

Period of study (months)	Group	No. of subjects	Hb Initial Mean	Hb Initial SE	Hb Final Mean	Hb Final SE	Increase Mean	Increase SE	Statistical significance of difference between experimental and control groups
	Boys								
12	Experimental	222	121	1·0	134	1·0	14***	0·9	$P < 0·001$
	Control	92	123	1·9	120	1·5	−3·9**	1·5	
	Girls								
	Experimental	161	137	1·5	148	1·1	11***	1·5	$P < 0·02$
	Control	71	126	1·8	131	1·9	5**	1·8	
	Boys								
18	Experimental	97	119	2·2	134	1·5	15***	1·7	$P < 0·001$
	Control	54	125	2·8	125	2·4	−0·5NS	2·32	

NS, not significant.
* $P < 0·05$, ** $P < 0·01$, *** $P < 0·001$.

Fe absorption from the fortified salt was determined in a small group of five children at the end of the study. All the children had normal Hb values at the time of this determination. The mean Fe absorption in these children was found to be 0·034 (Table 4). This value is similar to that reported previously from this Institute and obtained with cereal-based diets (Narasinga Rao, 1978).

The Fe content of the diet in the control schools was found to be 20–25 mg/d and in the experimental school 35–40 mg/d, which included Fe contributed by the Fe-fortified salt.

The reduction in Hb in the control group could not be traced to any episode of infection occurring during the course of the study. The possibility that the change from the home diet of these children to the school diet was a possible cause of the observed fall was considered. To test this possibility, children (boys) with more than 130 g Hb/l were registered immediately after their admission into these schools and were followed for a period of 6 months. It was observed that children with higher Hb values (> 130 g/l) showed a reduction, similar to that observed earlier, within 2 months (from 146 ± 2·28 to 133 ± 2·47 in one school and from 138 ± 1·31 to 128 ± 1·82 in the other school) of admission and maintained at that level subsequently. This observation was made in both groups, which had been divided previously into experimental and control groups. However, it was interesting to note that when the children were on fortified salt such a fall did not occur even in those who had high levels of Hb. This suggests that Fe-fortified salt not only helped to improve the Hb level in the anaemic group but also helped to prevent a fall which would otherwise have occurred.

As pointed out earlier, many attempts have been made in different countries to fortify different food items with Fe. However, the results of tests to evaluate the efficacy of these programmes have been varied. Fe in the form of ferrous sulphate at a level of 10 mg elemental Fe/individual per day was reported to be beneficial to prisoners in Mauritius (Stott, 1960). Similarly Fe in the form of FeNa–EDTA added to fish sauce to give 1 mg Fe per ml also produced a significant increase in PCV in Thailand (Garby & Arekul, 1974). Even though fortification of wheat flour with Fe is in vogue in many Western countries, very few systematic studies have been carried out to evaluate the efficacy of these programmes (Baker & DeMaeyer, 1979). Large-scale population studies in the UK (Elwood, 1968; Elwood *et al.* 1971)

Table 2. *Change in haemoglobin (Hb) levels (g/l) in residential Indian schoolchildren with different initial Hb values after feeding iron-fortified common salt (sodium chloride) for* 1 *year*

(Mean values with standard errors; no. of subjects given in parentheses)

Hb level g/l . . .	< 120		120–140		> 140	
Group	Mean	SE	Mean	SE	Mean	SE
Boys						
Experimental						
Initial	108(112)	1·0	128(90)	0·5	147(20)	1·4
Final	126	1·3	140	1·3	153	1·8
Difference†	18***	1·3	12***	1·2	6**	1·8
Control						
Initial	106(34)	2·5	131(44)	0·9	149(14)	1·9
Final	111	2·9	124	1·5	131	2·0
Difference†	5·0*	2·5	−6·0***	1·6	−18***	2·9
t value for difference between experimental and control group†	4·87***		8·59***		3·61**	
Girls						
Experimental						
Initial	104(25)	2·9	130(54)	0·8	152(82)	1·0
Final	137	3·7	146	1·7	153	1·0
Difference†	32***	4·4	16***	1·8	0·9 NS	1·4
Control						
Initial	110(24)	2·3	129(37)	0·8	150(10)	2·4
Final	120	3·8	135	2·0	140	3·1
Difference†	11**	3·1	6****	2·1	−11****	3·5
t value for difference between experimental and control group†	3·93***		3·78***		2·77**	

NS, not significant.

* $P < 0·05$, ** $P < 0·01$, *** $P < 0·001$, **** $P < 0·02$.

† The mean differences within the groups were tested by using a paired *t* test, while the differences between the control and experimental groups were tested using the Student's *t* test.

Table 3. *Percentage prevalence of anaemia* before and* 1 *year after the introduction of iron-fortified common salt (sodium chloride) to residential Indian schoolchildren*

Group	No. of subjects	Initial	Final
Boys			
Experimental	222	53·7	19·4
Control	92	42·7	51·9
Statistical significance of difference†	—	NS	$P < 0·001$
Girls			
Experimental	161	15·5	3·0
Control	71	33·8	22·5
Statistical significance of difference†	—	$P < 0·01$	$P < 0·001$

NS, not significant.

* Anaemia < 120 g haemoglobin/l.

† Analysis carried out using the test of proportions.

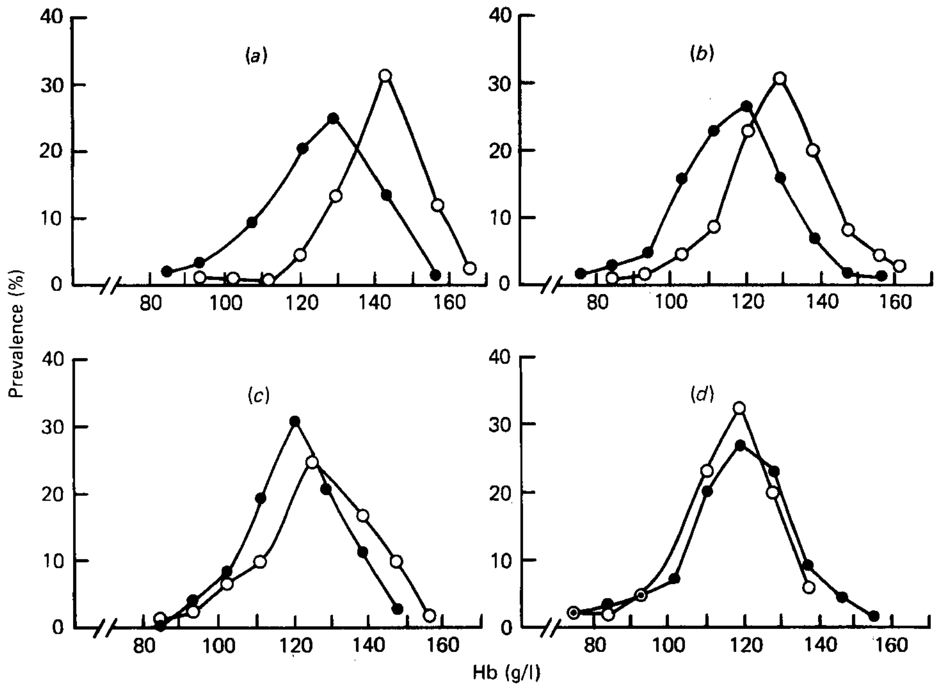

Fig. 1. Frequency distribution of haemoglobin (Hb) levels (g/l) in residential Indian schoolchildren before (●——●) and 1 year (○——○) after feeding iron-fortified common salt (sodium chloride). (*a*), Girls, experimental; (*b*), boys, experimental; (*c*), girls, control; (*d*), boys, control.

Table 4. *Iron absorption from Fe-fortified common salt (sodium chloride) in residential Indian schoolchildren*

Subject no.	Haemoglobin (g/l)	Absorption		Fortified salt:$FeSO_4$
		^{55}Fe salt	$^{59}FeSO_4$	
1	132	0·0485	0·1000	0·485
2	128	0·0351	0·0220	1·594
3	128	0·0421	0·0720	0·586
4	123	0·0114	0·0420	0·272
5	128	0·0328	0·0250	1·310
Mean	128	0·0340	0·0520	0·850

have however shown that consumption of Fe-fortified bread was not associated with any beneficial effect on haemoglobin status of the population. There may be two explanations for the failure to demonstrate any beneficial effect of some of the Fe-fortification programmes. One is the low level of Fe used for fortification. In the UK studies, bread was fortified at 35 mg/kg flour and additional intake of Fe through fortified bread was only 2·7 mg/d. In the present study, however, salt was fortified at a higher level of iron, i.e. 1000 mg/kg, and additional intake of iron through fortified salt was 15 mg/d. The other factor is the type of Fe used for fortification. The powdered reduced Fe used in the fortification of bread in the UK has been shown to be poorly absorbed from bread (Elwood, 1968). Iron in fortified salt on the other hand is absorbed as well as dietary iron. An additional factor operating in the present study is that the children studied here were a captive group and the daily intake of Fe-fortified salt by them was ensured, which was probably not the case with fortified bread in population studies reported from the UK (Elwood, 1968).

Based on the amount of salt obtained from the Institute it was found that the average per capita consumption of salt in these children was approximately 15 g/d. This value was reflected in the dietary Fe content. The mean increase in Hb observed over a period of 1 year (14 g/l) is well within the expected rise, as it accounts for approximately 70% of the Fe absorbed by these children, calculated on the basis of the observed absorption of 0·034.

Throughout the study period of 1·5 years no untoward effect which could be traced to the intake of fortified salt was observed. There was no complaint from the children about the colour of the salt or the taste of foods prepared using fortified salt.

The results of the study thus demonstrate the beneficial effects of the use of Fe-fortified salt. It helped improve Hb levels in the anaemic group and prevented deterioration in children with normal Hb values. It must however be pointed out that the children studied were in an urban setting and do not represent people living in rural areas. Before the use of Fe-fortified salt can be recommended for the prevention of anaemia in the population, large scale community-based studies which include rural population have to be undertaken. Such studies have now been initiated at different centres in the country.

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