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Micronutrient Deficiencies and Morbidity in Indian Rural Pre School Children

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KEYWORDS Fortified Biscuits. Vitamin A Deficiency. Prevalence Rate. Incidence Rate. Acute Respiratory Infections. Anaemia.

ABSTRACT The investigation was undertaken with the objective of evaluating the impact of interventions (food and nutrient) on health status of preschool children at different intervals on withdrawal of interventions. 205 preschool children attending Anganwadi centers (functional unit of a national women and child welfare program) from rural areas near Mysore city, a district of Karnataka State, Southern India were enrolled. Nutrition and health status was assessed. Children were divided into five groups based on economic status with statistician's assistance for intervention. Each group constituted 30-50 children. Two groups were supplemented with biscuits fortified with calcium, iron and vitamin A, another two groups received the fortificants in the tablet form on alternate days for a period of 6 months. One of the two groups in both the categories were priorly dewormed. One group served as control. The impact of the programme evaluated at the end of 6 months showed a reduction in the occurrence and duration of illnesses. On withdrawal of interventions, morbidity rates of all the groups reverted to their pre-intervention state but the extent of reversion was comparatively higher in the control group. A significant improvement in hemoglobin status, lowering of duration and incidence of illnesses at the end of intervention and deterioration of health status six months after withdrawal of interventions clearly demonstrated benefits of nutrient supplements.

INTRODUCTION

Malnutrition and infections often coexist in underprivileged communities, the presence of one predisposing and aggravating the other. Hence the relationship between the two are considered mutually causative or bi-directional. Essential nutritional deficiencies apart from causing growth faltering is also known to impair various facets of immune system thereby reducing the host resistance to infectious agents (Bahl et al., 1995; Reddy, 1987; Srikantia et al., 1976; Underwood, 1996). In children affected with xerophthalmia, the relative risk was found to be twice for acute respiratory infections (ARI) and thrice for diarrhoea, irrespective of their somatic status (Sommer et al, 1986). After the onset, the course of the infection was further known to be determined by the degree of deficiency (Damodaran et al., 1979; NIN, 1983).

Evidences have suggested that the immunological alterations occurring in the essential nutrient deficiencies were reversible on replenishment of the respective nutrients (Bhaskaram et al., 1989; Bothwell and Charlton, 1970). Some intervention trials have demonstrated that iron/vitamin A supplementation reduces the incidence of acute respiratory infection (ARI) and gastro-intestinal disorders (GID) (Barreto et al., 1994). Conversely others have demonstrated that iron supplementation increases the susceptibility to infections and vitamin supplementation does not have any significant effect on morbidity (Beaton et al., 1993; Hussey et al., 1990; Ramakrishna et al., 1995). But iron supplements in combination with vitamin A showed a significant reduction in the markers of infection (Bloem et al., 1997; Meija et al., 1977; Meija et al., 1997) as both the deficiencies are often co-existent.

Research has shown that nutrition intervention reduces the morbidity in children, but information on health status on withdrawal of interventions are lacking as the study designs had not included the follow up component. Hence the investigation was undertaken with the objective of assessing the effect of food and nutrient supplements on the morbidity profile of rural preschool children over a period of time after withdrawal of supplementation and to observe the sustenance and efficacy of food and nutrient supplements.

MATERIALS AND METHODS

This study was longitudinal and carried out in three phases viz, one year of observation

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(health and nutritional status), 6 months of intervention dispensal and 6 months of follow-up after withdrawal of interventions. 205 children between the age of 1-5 years were selected by purposive sampling from rural areas near Mysore (a district of Karnataka State in Southern India). A baseline survey was conducted to obtain information on the socio-economic status of the families.

Assessment of Nutritional Status: The children were clinically examined for symptoms of iron deficiency anaemia (IDA), vitamin A (ocular) and B-complex deficiencies with the help of a medical doctor. Haemoglobin (Hb) status of the children was assessed with the prior consent of their parents. Blood samples collected by finger prick method were analyzed by cyanmethemoglobin method. The children were categorized into different grades of anaemia as per the WHO standards (Demaeyer et al, 1989).

Assessment of Health Status: Mothers of the children served as respondents for reporting child's morbidity. Initially the mothers were informed about the significance of the study and were requested to observe the infections their children contract and report it to the investigator on her visit. Information on the prevalence, occurrence and duration of all illnesses the children suffered were recorded in a pretested questionnaire on fortnightly basis for a period of one year. For the purpose of computation, the illnesses were grouped as total morbidity (all illnesses pooled), acute respiratory infection (ARI), fever, gastro-intestinal disorder (GID) and others. Percent prevalence rate (PR) and incidence rate (IR) were computed every month and duration once in 6 months as per WHO (WHO, 1993).

Intervention Programs: Agriculture was the main occupation of study population. They either owned small plots of land or worked as agricultural labourers with unstable incomes. Since a major part of their income was spent on food, the food expenditure/consumption unit/month was taken as an index of economic status. For the purpose of intervention, the children were categorised into 5 groups based on the economic status with the help of a statistician, there were no significant differences in the economic status between the groups (P=0.06). Each group consisted of 30-50 children (Table 1), two groups received a food supplement i.e, 4 biscuits (25g) fortified with iron, calcium and vitamin A (providing energy – 419 kj, protein - 2.3g, calcium - 50mg, iron - 3.0mg, vitamin A –150 IU and fat - 3.0g). The biscuits were formulated with the help of Central Food Technological Research Laboratories, Mysore. Two groups received the fortificants in the form of tablets (providing 20mg elemental iron/day as ferrous sulphate, 40mg calcium/day as calcium lactate and 50,000 IU of vitamin A every two months). One group among both categories was dewormed prior to intervention with 150mg mebendazole (given as three tablets of 50mg each on consecutive days). The fifth group with no intervention served as control.

Table 1: Percent prevalence of malnutrition and morbidity in children (Baseline data)

Clinical manifestations	*Prevalence (%)*
Iron deficiency anaemia (IDA)	62-85
Vitamin A Deficiency (Bitot spot)	5-11
Riboflavin deficiency (angular stomatitis)	6-24
IDA (haemoglobin levels)	Moderate – 73 Severe – 25
Morbidity Profile (PR)	
Acute respiratory infections	34-58
Fever	3-11
Gastro intestinal disorders	2-11
Other infections	2-9

All the supplements were provided on alternate days for a period of 6 months under supervision. General medicines were given for minor ailments for all the groups including the control group. A lady doctor's service was provided to entire study group once a month. Though it was envisaged that this could reduce the morbidity load to some extent, for ethical reasons and to build up rapport this was very much essential. Children were kept under surveillance for morbidity profile during (6 months) and after the withdrawal of interventions (6 months).

Evaluation of Intervention Programme: Impact of the intervention programmes was assessed by adopting pre-tested indicators like clinical examination, haemoglobin status and morbidity profile on completion and 6 months after the withdrawal of interventions. Improvement in the health status of index children was assessed by comparing the pre and post intervention data of same season. The data was subjected to suitable statistical analysis with the help of a statistician.

Frequency distributions were used to obtain descriptive statistics, to calculate the percentage prevalence rate of infections, degrees of anaemia and deficiency diseases. Pearson Chi-square was used to observe the impact of interventions on the nutritional and health status of the children using a statistical package INSTAT. One way ANOVA specially designed to test the difference between the groups having unequal numbers was used. Probability level was fixed at P<0.05.

RESULTS AND DISCUSSION

The selected villages were covered by Primary Health Care Services, but the centers offering services were not easily approachable from the villages. There was no access to medical care within the study areas.

Haemoglobin assessment revealed that 73 and 25% of the children were suffering from moderate to severe degrees of anaemia respectively (Table 2), 5-11% of children exhibited Bitot spots (vitamin -A deficiency) and 6-24% angular stomatitis (riboflavin deficiency). Of the infections registered, ARI (cold, cough, sore throat), fever (increased body temperature) and GID's (diarrhoea, nausea, vomiting, abdominal pain) were prevalent to a large extent.

The interventions were dispensed off for a period of six months and the impact assessed at different time intervals are discussed in two stages as follows.

(i) Evaluation of the Intervention Programmes at the Completion of the Programme: Clinical examination of the children revealed 21-56% reduction in the manifestations of iron deficiency aneamia in all intervention groups as against a 17% increase in the control group (Table 3). The occurrence of Bitot spots completely disappeared in the tablet groups, remained stable in the biscuit groups but showed a small increase in the control group. Reassess-ment of haemoglobin status after the completion of intervention showed a decline in the pre-valence of anaemia. The extent of reduction was found to be 20-25% in the biscuit groups and by 18-46% in the nutrient supplemented groups (Table 4). The extent of improvement was found to be extremely significant in the parasite treated groups. This confirms the earlier findings across the country (Seshadri et al., 1984., Sood et al,1975).

As seen from Table 5, the PR of total morbidity and ARI reduced by around 10-20% in the intervention and 20% in the control groups. PR of fever and GID showed a reduction of 2-10 and 3-6 respectively in different groups. All category illnesses reduced during the intervention period compared to their pre-intervention state of the same season. The extent of reduction was found to be statistically significant in one of the nutrient (-D) groups. Though the extent of improvement witnessed by other intervention groups were not significant, biological signifi-cance is considerable. Antihelminthic treatment did not have any impact on the prevalence of total morbidity either among the biscuit ($\chi^2 = 1.64^{ns}$) or the tablet groups ($\chi^2 = 3.59^{ns}$). It was interesting

Table 2: Mean Age of children of different intervention groups

Group	*Number*	*Age (years)*
Biscuit+D	35	3.01 $\pm$ 1.19
Biscuit-D	34	2.95 $\pm$ 1.40
Nutrient+D	41	3.19 $\pm$ 1.20
Nutrient-D	56	2.98 $\pm$ 1.07
Control	40	2.77 $\pm$ 1.01

D - Deworming

Table 3: Impact of interventions on the manifestations of nutritional deficiencies (%)

Group	*Intervention Period*	*Normal*	*Iron def. anaemia*	*Bitot spots*	*Angular stomatitis*	χ^2
Biscuit +D	Before	31	69	-	6	48.24***
	After	77	20	-	3	
Biscuit –D	Before	18	74	6	24	9.19 ^{ns}
	After	47	53	6	6	
Nutrient +D	Before	10	85	10	20	35.48***
	After	63	29	-	5	
Nutrient -D	Before	30	66	11	14	13.21*
	After	55	41	-	11	
Control	Before	33	62	5	18	3.21 ^{ns}
	After	18	79	8	26	

ns- not significant, * - significant at 5% level, *** - significant at 0.1% level

Table 4: Impact of interventions on prevalence of anaemia based on haemoglobin levels (%)

Group	*Intervention period*	*Degrees of anaemia*				χ^2
		Normal	*Mild*	*Moderate*	*Severe*	
Biscuit +D	Before	-	-	69	31	13.33*
	After	25	13	56	6	
Biscuit –D	Before	-	4	79	17	7.90***
	After	21	7	65	7	
Nutrient +D	Before	-	-	50	50	13.07*
	After	18	21	59	2	
Nutrient -D	Before	-	-	80	20	9.80*
	After	46	10	44	-	
Control	Before	1	-	74	23	4.89 ns
	After	-	-	80	20	

ns- not significant, * - Significant at 5% level, ***- Significant at 0.1% level

Table 5: Difference rate (before and during intervention) of prevalence rate of illnesses

Group	*Total morbidity*	*ARI*	*Fever*	*GID*	*Other infections*	χ^2
Biscuit +D	11	12	6	5	2	3.78 ns
Biscuit –D	23	21	10	4	1	2.37 ns
Nutrient +D	20	20	2	6	7	7.31 ns
Nutrient –D	15	11	4	3	5.7	13.33*
Control	22	20	2	5	2	6.00ns

ns- not significant, * - Significant at 5% level

to note that even the control group witnessed a similar rate of improvement in the prevalence of the illnesses as that of the intervention groups (P>0.05), which could be due to medical services provided.

The epidemiological and clinical evidences that have associated the role of vitamin A/iron supplements on the PR of illnesses are highly contradictory, the studies that have demonstrated a positive impact are very few and only on diarrhoeal morbidity and not on ARI (Hussey et al., 1990). A reduction in the PR of all category illnesses in the present study shows the superiority of multinutrient supplementation.

Duration of all illnesses was lower during intervention period in comparison to the pre-intervention period of same season, but extent of lowering varied between the groups (Table 6). Duration of cold was similar in biscuit +D group (P= 0.934) but decreased by 14 days in biscuit –D group (P= 0.051), cough showed a reduction of 2.5 and 6.0 days in the biscuit +D (P= 0.077) and biscuit –D (P = 0.070) groups respectively. Biscuit +D group showed a significant reduction of 4 days for fever (P= 0.002) and 2 days for diarrhoea (P= 0.012). The extent of lowering was 2.4 days for fever (P=0.046) and 1.4 days in biscuit –D (P=0.107) group. An average of 10 and 5 days reduction in duration of cold was observed in the nutrient+D (P= 0.276) and nutrient-D (P= 0.176) groups respectively. Cough reduced by 9 days in nutrient+D (P= 0.003) group and 10 days in nutrient-D (P= 0.123) group. Reduction of fever was considerable in nutrient+D (P= 0.183) and nutrient-D (P= 0.526) groups. Diarrhoea showed a higher reduction in helminth treated nutrient (P = 0.009) group than its untreated counterpart (P = 0.095) during the intervention period. In control group duration of cold was lowered by 3 days (P=0.57), cough by 6 days (P= 0.006), fever by 1.7 days (P= 0.050) in the intervention period.

Among the intervention groups, the parasite treated groups showed comparatively better performance (P<0.05). This showed that antihelminthic drugs apart from serving as a pre-requisite for effective nutrient supplementation also reduced the morbidity load.

Several investigators have demonstrated that Vitamin A (known as anti-infective agent) supplementation had no impact on duration of either ARI or diarrhoeal morbidity, a positive improvement evidenced in three of the intervention groups in our study stresses the need for multinutrient supplementation.

The incidence of cold (Fig 1.) showed an

Table 6: Effect of intervention on duration of illnesses

Group	*Intervention period*	*Cold*	*Cough*	*Fever*	*Diarrhoea*
Biscuit +D	Before	18.57	6.06	4.23	2.63
	During	18.09	3.46	0.19	0.54
$SD^{(1df)}$		$\pm$ 7.75	$\pm$6.05	$\pm$ 4.27	$\pm$ 3.38
$F^{(1,68)}$		0.01^{ns}	3.22^{ns}	10.53**	6.66*
Biscuit –D	Before	31.06	11.97	3.97	2.00
	During	17.85	5.97	1.56	0.64
$SD^{(1df)}$		$\pm$ 27.40	$\pm$ 13.45	$\pm$ 4.89	$\pm$ 0.55
$F^{(1,66)}$		3.95^{ns}	3.38^{ns}	4.13*	2.66^{ns}
Nutrient +D	Before	26.95	14.10	1.82	1.18
	During	21.98	5.56	1.45	0.30
$SD^{(1df)}$		$\pm$ 19.28	$\pm$ 12.92	$\pm$ 3.12	$\pm$ 2.75
$F^{(1,80)}$		1.20^{ns}	8.95*	1.80^{ns}	7.98*
Nutrient -D	Before	38.56	9.41	3.46	2.24
	During	32.70	6.59	1.88	0.46
$SD^{(1df)}$		$\pm$ 19.28	$\pm$ 9.62	$\pm$ 5.34	$\pm$ 3.02
$F^{(1,80)}$		1.85^{ns}	2.42^{ns}	0.40^{ns}	2.83^{ns}
Control	Before	27.46	13.43	3.00	1.28
	During	24.36	5.87	1.36	0.92
$SD^{(1df)}$		$\pm$24.03	$\pm$ 11.97	$\pm$3.64	$\pm$ 2.16
$F^{(1,80)}$		0.32^{ns}	7.78*	3.96^{ns}	0.21^{ns}

ns- not significant, * - Significant at 5% level, ** - Significant at 1% level

average reduction of 0.4 in biscuit+D group (P= 0.002), by 2.9 in biscuit-D group (P= 0.005), by 1.8 in nutrient+D (P=0.006) group, by 4.0 in nutrient -D (P= 0.320) group and by 1.0 in control (P= 0.005) group in the intervention period compared to their pre-intervention period of same season. Attack rate of cough declined by 0.8 in the biscuit +D (P=0.000), by 1.0 in biscuit-D (P=0.001), by 1.3 in nutrient +D (P=0.005), by 0.8 in nutrient -D (P = 0.0004) and by 1.1 in control group in relation to the IR of pre-intervention period. These results show that supplements were effective in reducing the attack rate of cold and cough. The extent of reduction of cough was found to be similar in all groups, but cold showed a highly significant reduction in both biscuit and parasite treated nutrient groups.

On an average the incidence of fever reduced by 0.6 episodes in Biscuit +D (F=11.17**) and biscuit –D (F= 4.72*) groups that was statistically significant. But the reduction observed in the nutrient +D ($F=1.00^{ns}$) and nutrient -D ($F= 1.44^{ns}$) groups was non-significant. The average decrease in diarrhoea was 0.3 in biscuit + D (F=3.63*), 0.2 in biscuit – D ($F= 2.37^{ns}$), 0.4 in nutrient +D (F=7.98*), 0.2 in nutrient –D ($F= 3.11^{ns}$) and 1.2 in control groups (F = 5.83*). A statistically significant reduction in IR of diarrhoea by the parasite treated groups signifies the role of antihelminthic therapy. But a significant improvement evidenced by the control group shows that even medical intervention was effective in reducing the morbidity load.

Majority of the studies have consistently reported a lack of impact of nutrient intervention on the IR of ARI or dirrahoeal morbidity (Bhandari et al., 1994; Seshadri et al., 1984; Sood et al., 1975) but in the present study a significant reduction in the attack rate of ARI (cold in 3 and cough in all 4 groups) and diarrhoea (in 2 of the intervention groups) suggests the appropriateness of multinutrient supplementation.

From the above observations it is seen that the rightward shift evidenced in the health status is a clear reflection of the improved micronutrient status. Our study also confirms the earlier results that have shown that the immunological alterations occurring in the essential nutrient deficiencies could be corrected through the replenishment of the respective nutrients.

(ii) Evaluation of the Intervention Programmes After 6 Months of Withdrawal of Interventions: On withdrawal of interventions the PR of infections showed an increasing trend in all the groups, but the period at which the trend got reverted varied between the groups. As seen from Fig 2, PR of illnesses shot up immediately on withdrawal in the control group, 2 months later in the nutrient-D and 3-4 months later in other groups. The average PR of ARI computed for the

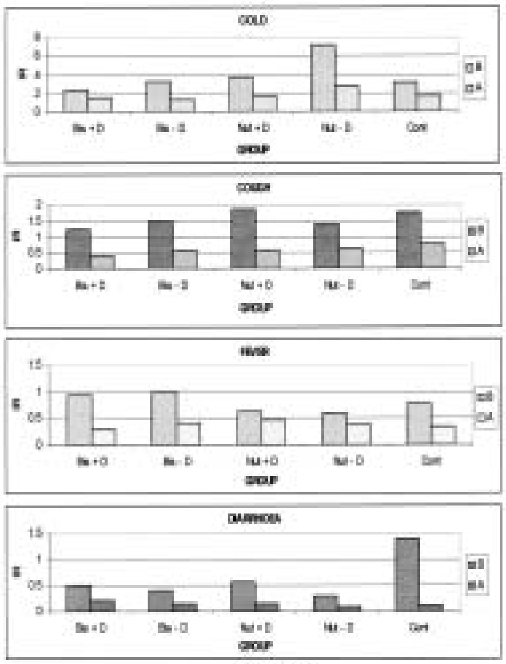

Fig. 1. Impact of interventions on Incidence Rate (IR) of illnesses

Bis – Biscuit	Cont - Control
D – Dewormed	B - Before intervention
Nut – Nutrient	A – After intervention

post-intervention period was higher by 10% in biscuit+D, 5% in biscuit-D, 16-17% in nutrient and control groups than their intervention period. The average PR for fever and GID was comparable to the intervention period in the supplemented groups but increased by 1.5 and 2.0 times respectively in the control group. This shows that medical intervention was just 'curative' but not 'corrective'.

On withdrawal of interventions slight changes occurred in the duration of illnesses (Table 7) in comparison to the intervention period. Of the biscuit groups the parasite treated group showed a lesser increase in cold (P = 0.392) than its untreated counterpart (P= 0.167ns). Duration of cough reduced in both the groups. The changes that occurred were found to be non-significant as per ANOVA. Of the nutrient groups parasite treated group showed a notable increase in cold (P=0.483) and a slight increase in cough (P= 0.885), but its untreated counterpart showed significantly higher increase in cold (P=0.013) and a slight reduction in cough (P=0.873). Control

Table 7: Difference rate of duration of illnesses between intervention and post intervention period (in days)

Group	*Cold*	*Cough*	*Fever*	*Diarrhoea*
Biscuit +D	↑ 4.1^{ns}	↓1.7 ^{ns}	↑0.5 ^{ns}	↑0.1 ^{ns}
Biscuit –D	↑12.9 ^{ns}	↓14.3*	-	↑0.3 ^{ns}
Nutrient +D	↑17.5 ^{ns}	↑2.2 ^{ns}	-	↑0.6 ^{ns}
Nutrient - D	↑19.6**	↓1.8 ^{ns}	↓0.6 ^{ns}	-
Control	↑17.0*	↑0.3 ^{ns}	↑1.1 ^{ns}	↑2.3 ^{ns}

*- Significant at 5% level, ** - Significant at 1% level,
ns- not significant '-' no change, '↑'- increase, '↓'- decrease

group showed a significant increase in cold (P= 0.047) but duration of cough was comparable to the intervention period (P =0.067). Duration of fever and diarrhoea was notably higher than the intervention groups.

From these observations it can be inferred that the performance of the supplemented/intervention groups was better than the control group. Of the intervention groups health status of biscuit +D group was better followed by biscuit -D group and nutrient +D group.

Incidence of all infections showed a slight reduction in the post intervention period in both biscuit and nutrient +D groups (Table 8). Nutrient –D group showed a significant increase in the incidence of cold but the incidence of cough and fever were slightly lower and diarrhoeal morbidity was comparable to the intervention period. The incidence of all the infections showed an increase (the increase was significant for cold) in the control group compared to intervention period.

Table 8: Difference rate of incidence of illnesses between intervention and post intervention period (in episodes)

Group	*Cold*	*Cough*	*Fever*	*Diarrhoea*
Biscuit +D	↑0.4 ^{ns}	↓0.9 ^{ns}	-	↓0.1 ^{ns}
Biscuit –D	↓0.1 ^{ns}	↑1.2*	↓0.1 ^{ns}	↓0.1 ^{ns}
Nutrient +D	↓0.3 ^{ns}	↑0.1 ^{ns}	-	↓0.1 ^{ns}
Nutrient – D	↑0.6**	↓0.1 ^{ns}	↓0.2 ^{ns}	-
Control	↑0.7*	↑0.3 ^{ns}	↑0.3^{ns}	-

ns- not significant, * - Significant at 5% level, ** - Significant at 1% level, '-' no change
'↑'- increase, '↓'- decrease.

From the above results, a better performance of the intervention groups is clearly evident in comparison with the control group even on withdrawal of interventions.

Assessment of haemoglobin levels and comparison with the intervention period revealed a reversion in all the groups. The extent of

Table 9: Changes in prevalence of anaemia on supplementation and withdrawal of interventions

Group	*Intervention and post intervention period* χ^2	*Pre and post intervention period* χ^2
Biscuit +D	2.73 ns	6.00 ns
Biscuit –D	3.33 ns	4.00 ns
Nutrient +D	10.89*	1.47 ns
Nutrient - D	7.39*	1.50 ns
Control	00	4.89 ns

ns- not significant, *- Significant at 5% level

reversion in the biscuit group was to a non-significant (Table 9) level but the nutrient group showed a significant deterioration in 6 months after withdrawal of interventions. Control group showed no change. A non-significant association in the haemoglobin status between the pre-intervention and post-intervention period is suggestive of a comparable prevalence of anaemia or a reversion from intervention to their native/ pre-intervention state.

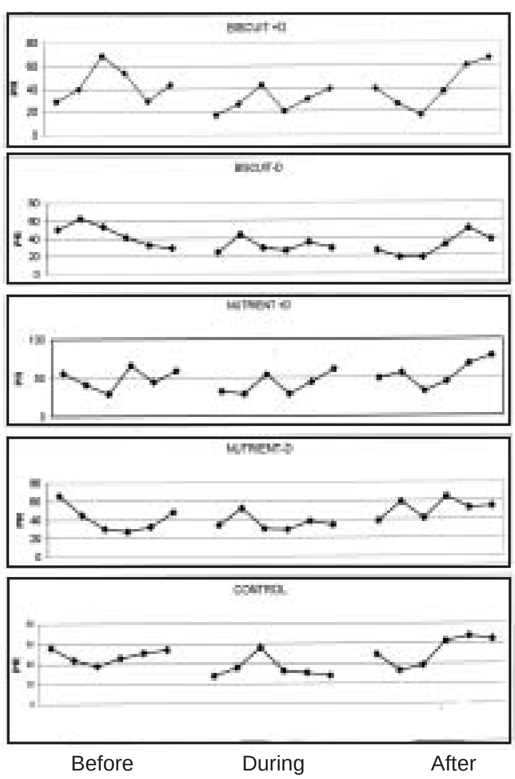

Fig. 2. Monthly Prevalence Rate (PR) of illnesses before during and after interventions

CONCLUSION

An improvement in the micronutrient status (assessed by clinical examination and haemoglobin levels) and health status was observed on completion of intervention period. A gradual deterioration in health status was observed on withdrawal of interventions but the extent and period at which it got reverted varied by the supplements. Food supplemented groups showed a comparatively better performance, which might be due to the combination of iron and vitamin A at each dose. Assessing the impact of interventions on withdrawal of interventions apart from showing the potency of the intervention components also shows the extent of intervention for correction of the problem and for sustainability of the improvement achieved. Thus it can be said that in areas where micronutrient deficiencies are extremely high (due to dietary inadequacies), regular supplementation is essential for correction of nutritional status and thereby for improvement of health status.

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