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Effect of Iron Supplementation in the Prevention of Anemia Associated with Malaria in Children Aged 6 to 59 Months in Bakperou (Benin) in 2013

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Abstract

Introduction: Anemia is a largely widespread public health issue, with major consequences on human health and the economic and social development.

Objective: To determine the effect of iron supplementation in the prevention of anemia in children aged 6 to 59 months having malaria in the village of Bakperou (Benin) in 2013.

Setting and methods: It was an interventional study carried out in two phases in a village of Parakou (Bakperou) from 15 may to 30 September, 2013. A descriptive phase including 236 children among whom 70, divided into two groups of 35 each, were selected for the experimental phase. One group had received an iron supplementation of 2mg/kg/day during a period of two months. The second group had not received any supplementation.

Results: The mean age of the included children was 33.2 ± 13.5 months. In the supplemented children, the mean age was 32.0 ± 13.1 months for 34.5 ± 13.9 in the non- supplemented ones. The most represented sex was the female (63.3%). Sex ratio was 0.6. In the supplemented ones, female percentage was 56.7% and 66.7% in the non-supplemented. The incidence of malaria was 63.3% IC95% [49.9% - 75.4%]. In the supplemented children, incidence of anemia in children having malaria was 43.3% IC95% [25.5% - 62.6%] and 73.3% IC95% [25.5% - 62.6%] in the non-supplemented. The non-supplemented children ran twice more risk of having anemia with malaria than supplemented ones (p<0.05).

Conclusion: Iron supplementation of infants and children in the village of Bakperou (Parakou) proved to be efficient and enable to implement a supplementation program in order to reduce anemia associated with malaria in children.

Keywords: Anemia; Malaria; Iron supplementation; Children; Benin

Introduction

Anemia is a largely widespread public health issue, with major consequences on human health and the economic and social development [1]. Children under five are among the most affected. According to World Health Organization (WHO), in 2003, anemia has affected in Africa, 45 million children under 5 years, 58 million women in child bearing age and 11 million pregnant women [2]. In Mali, more than one child in four suffer from severe anemia. According to the 4th Survey on Demography and Health in Benin ("Enquête de Démographie et Santé Bénin IV"/EDS - B IV) conducted in 2011, anemia prevalence is 58.3% in children under 5 years including 26.2% of mild, 29.1% of moderate and 3% of severe form [2,3]. In children, anemia prevalence is the highest one in the Atacora Region (89%) compared with the one of the town of Cotonou where it is lower (50%) [4]. One of the most noxious effects of anemia, particularly severe anemia, is the increased risk of mortality in the child [5]. Iron deficiency is the main cause of anemia. Infectious diseases, especially malaria, are important factors that contribute to high prevalences of anemia among several populations in Sub-Saharan Africa countries [1].

Malaria, which is a disease caused by protozoan of Plasmodium species and transmitted by the bite of infected female anopheles, remains one of the major plagues in the tropical zone [6].

Severe anemia is among the 15 criteria of the severe malaria, formulated by the WHO. With or without fever, children with moderate to severe anemia are recruited above all among the ones in whom parasitemia is important compared with plasmodium-free children [7]. The load of malarial anemia estimated in terms of disability-adjusted life year (DALYs) is very important in Africa where mortality is very high in children [8]. The physiopathological mechanism manifests itself through destruction of erythrocytes or through dyserythropoiesis associated with some etiologic factors [9]. A policy supporting iron supplementation and malaria control would allow reducing the incidence of severe anemia and probably deaths [10]. In the areas where anemia prevalence reaches 20% or more among children in preschool or school age, the WHO recommends a periodic iron supplementation as public health intervention meant for improving ferric balance and for reducing risk of anemia in the child [11]. However, some controversial topics and unsolved questions are still prevailing, particularly those related to the relations between iron supplementation of young children with no iron deficiency and malaria. Additional researches are necessary. According to the new

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recommendations of the WHO, iron deficiency anemia should be screened among young children in the areas where malaria is endemic before any iron supplementation in these children. Evidences indicate a decline of the resistance to infection in iron deficient individuals [12]. In this context, we asked ourselves what was the effect of iron supplementation in the prevention of anemia in children presenting with malaria. That is the issue which aroused interest for this research work. The answer given by this research work could clarify certain current discrepancies on the role and impact of iron supplementation in the prevention of anemia in children presenting with malaria especially in rural settings.

Setting, Patients and Methods

Study setting

The study was done in the village of Bakperou located in the District of Parakou, North-Benin, 460 km far from Cotonou the capital city. Its population is estimated at 3531 inhabitants, according to the 2002 General Population and Housing Census [13]. Children aged 0 to 59 months represent 20% of the total population, i.e.707 children. In Bakperou, the type of climate is a tropical wet one (Sub-humid climate). It is characterized by the alternation of one rainy season (May to October) and one dry season (November to April). It is in December-January that the lowest temperatures are registered in Bakperou. Annual average precipitation is 1200 mm. The maximum one occurs between July, August and September. As far as economy is concerned, the main activities exerted by the populations are agriculture and animal farming.

As regards health, the area has three (03) private health care units. It is the Health Centre of Madina (which is the public health centre of one of the boroughs of the town of Parakou) that provides health care to this village. It carries out activities of immunization based on advanced strategy.

Type and period of study

It was an interventional prospective and analytical study carried out over a period of 4 months from 31 May to 30 September, 2013.

Study population and inclusion criteria

The study populations consisted of children aged 6 to 59 months with a negative thick blood smear and a hemoglobin level higher or equal to 9 g/dl, living in the village of Bakperou, their parent's informed consent was obtained.

The selection of children has been done through a multi-stage sampling. On the fisrt phase a door to door method has been used to screen all children aged 6 to 59 months in the village for malaria and anemia. All the children having a positive thick blood smear for malaria and less than 9 g/dl hemoglobin concentration were treated and excluded for the second phase of the study. Only chlidren having a hemoglobin level higher or equal to 9 g/dl with a negative thick blood smear for malaria were included for the experimental part of the study i.e. phase two. Among them, after having excluded children concerned by the exclusion criteria, a random selection was then made in order to form the two groups needed.

Exclusion criteria

Children having an iron supplementation in progress and/or who had been transfused within the period of one month before the start of the study, an acute or chronic malnutrition, a documented sickle cell disease, a high white cell count, or whose parents, during the study, for one reason or another, could not continue the study till its end were excluded from the study.

All the children meeting our selection criteria had been selected.

Two groups were formed. There was a group G_1 of children who were given an iron supplementation i.e. the exposed, the second one G_2 did not received iron supplementation i.e. the unexposed. A simple random selection was done so as to form the two groups.

Technique of group formation

The technique used was the following: one numbered list of all the children selected to participate to the study had been drawn up. It was given at random a number to each name. Then, the numbers were written on pieces of paper and put into a jar and a simple random selection/sample without replacement was done. The first number drawn at random corresponds to the first child of the group G_1 and the second number corresponds to the first child of the group G_2 till both groups were formed.

Each of the children of that village had previously benefitted from a clinical and paraclinical test enabling to select the children of both groups mentioned above.

Definition of the exposed

The group G_1 of the exposed consisted of children having a negative thick blood smear and a hemoglobin level higher or equal to 9g/dl. The children of this group had received an iron supplementation in the form of ferrous fumarate with a dose of 2mg/kg/day during 2 months in two administrations distanced from meals. Nutritional counseling (enriched porridge, egg, sesame, red meat, orange) and a deworming with one tablet of albendazole (400mg) taken once every 3 months has been provided to the children through their mothers. Iron was administered by the mothers of the children previously informed on the advantages and disadvantages of supplementation.

Definition of the unexposed

The group G_2 consisted of children having a negative thick blood smear examination and a hemoglobin level higher or equal to 9 g/dl. These children had not received iron supplementation but nutritional advices (enriched porridge, egg, sesame, red meat, orange) and systematic deworming with one tablet of albendazole (400 mg) taken once every three months.

Active surveillance

All the children had benefitted from a full physical examination and paraclinical tests such as thick blood smear, parasite count and complete blood count before inclusion. Once a week the children of both groups had benefitted from a clinical test at the end of a visit into the houses by the surveillance team. Thus, the caregivers of children were asked questions on the presence or not of symptoms two days before the visit. During these visits, blood sample was necessary only in case of appearance of symptoms like fever with temperature > 37.5°C, headaches, vomiting, chills or pallor.

Passive surveillance

A system of passive surveillance was set up in one of the health centers of the village. One nurse was installed on the site for the examination and samples, notification, treatment of simple malaria cases and early referral to the Borgou Regional Hospital of cases of severe anemia with malaria, of side effects or iron intolerance.

Assessment criteria

Any child who showed signs of anemia with a hemoglobin level below 11 g/dl and a thick blood smear test during the follow-up was considered as a case.

Anemia was defined as hemoglobin level less than 11 g/dl, microcytosis as mean corpuscular volume below 80 fl, and normocytosis as mean corpuscular volume between 80 and 90 fl. Hypochromia was defined as mean corpuscular hemoglobin concentration below 30 g/dl and normochromia as mean corpuscular hemoglobin concentration aver 30 g/dl.

Data collection

A face to face interview between investigator and respondent was done through a questionnaire. It had been completed with a physical examination and a venous blood sample.

Data analysis

Data were captured by means of the software EPI-data and analyzed with the software EPI INFO version 3.5.3. A comprehensive and compared description between the exposed ones and the unexposed ones was done. The quantitative data were presented in the form of average with standard deviation and qualitative data in the form of percentage. The relative risk (RR) was used for association measure and to appraise the strength of the different associations with their respective confidence intervals and their p values (p-value) at the threshold of 5%.

Ethical considerations

A verbal informed consent was obtained from the mothers of the children included before their inclusion. During the follow-up phase of the study all the parents who did not want to continue the study were authorized to stop the follow-up of their children within the framework of the study. Each child subject to sample who showed any kind of pathology was managed.

Results

A total of 60 children, aged 6 to 59 months were included in each of the groups G1 and G2 of the study after the withdrawal of 5 children of each of the two groups because of refusal to continue the study till its completion, for various reasons, out of 35 children initially included per group. Figure 1 shows details on children included into this study (Figure 1).

Child characteristics

Girls represented 61.67% of this population i.e. a sex ratio of 1.61. The subjects aged 12 to 36 months were the most represented (56.67%). The mean age was 31 months. Among the women mothers of the subjects of our study, it was noted a predominance of Islamic religion (66.67%). Those who have no educational background or are illiterate represented 73.33% of the whole number.

Details on the characteristics of the children included in the study are shown in Table 1.

(Table 1).

Among the children who received an iron supplementation during two months, i.e. 32% had their hemoglobin level improved.

No one of the 30 children exposed or unexposed, had a positive thick blood smear at the beginning of exposure. At the end of exposure 16 (53.3%) children had malaria (fever + positive thick blood smear). Any of the children did not show severe malaria, all the cases were simple malaria cases (Table 2).

In the exposed group, among the 28 children having a hemoglobin level < 11 g /dl, 16 had positive thick blood smear and anemia (57.1%). As well, among the 28 children, two (02) had not suffered from malaria (7.1%).

Any of the 2 children of the exposed group with a hemoglobin level > 11g/dl had neither anemia nor malaria. Reported to the whole group of exposed the 16 children who had suffered from malaria also showed anemia. Details on the characteristics of the infants exposed or not to iron supplementation in Bakperou are in Table 2. The evolution of mean hemoglobin level in the group is also shown in Table 2b.

Factors associated with iron supplementation of infants in Bakperou

The mother's educational background was significantly associated with the occurrence of anemia in the infants of Bakperou (p= 0.0009). The risk of having anemia was 4.3 times more elevated in children whose mothers had no educational background than in children whose mothers had at least attended primary school. The profession of the child mothers was also significantly associated with occurrence of anemia in the infants of Bakperou (p=0.0007). The children of farmer women ran 1.4 times more risk of having anemia than those of herder mothers. Except these factors, any of the other factors studied did not influence the occurrence of anemia in children exposed or not to iron supplementation in Bakperou. These were age (p=0.3), sex (p=0.2), ethnic group (p=0.2), religion of their mothers (p= 0.07) and civil status (p= 0.6). These details are shown in Table 3.

The incidence of malaria was 73.3% (n = 22) in the unexposed children whereas it was 53.3% in the exposed but the difference between the ratios was not statistically significant (p = 0.1) (Table 2a).

It was also noted more infection cases in the exposed than in the unexposed, without a statistically significant difference. These results are mentioned in Table 4.

The risk of having anemia associated with malaria was two times higher in the children unexposed to iron supplementation than in the children exposed to supplementation with a statistically significant difference.

Moreover, in the exposed ones, the incidence of anemia, malaria and anemia associated with malaria was lower than the one noted in the unexposed.

At paraclinical level, hypochromia and microcythemia had improved in the infants exposed to supplementation (p=0.0000014 and 0.00004 respectively). In the infants unexposed to supplementation, an improvement was paradoxically observed as regards microcythemia (p=0.0000228) (Table 5).

No iron intolerance (diarrhea, vomiting, nausea, chocolate stains on the teeth) was noted in the supplemented children. The two exposed children who had not anemia before had not suffered from neither malaria nor anemia at the end of follow-up.

Some mothers did not strictly comply with the rules related to tablet administration to children (Table 5).

Discussion

Through this research work, the authors have been able to identify the effect of iron supplementation in the prevention of anemia associated with malaria in children aged 6 to 59 months in Bakperou (Benin) in 2013 thanks to an interventionnal prospective and analytical study.

The target population of children aged 6 to 59 months constitutes a limited number in a village, this explains the small size of the different groups who were followed up. The homogeneity of the study population of experimental phase (group 1 and 2) had been shown in Table 1. The methodology used, which compares one group of exposed to supplementation with one group of unexposed by means of adequate statistical tests enabled us to state the validity of this work. Nevertheless, its limits are the incompleteness of the anemia biological explorations in both groups (reticulocytes count, serum iron, transferrin, G6PD measurement and hemoglobin electrophoresis).

In this research work, a child who had not received iron supplementation statistically runs 2 times more risk of having anemia associated with malaria than a child who had received iron supplementation. Many authors in Africa reported results identical to ours. For instance, the risk of occurrence of anemia associated with malaria was 0.4 times in Tanzania, 0.2 times in Nigeria and in Zambia lower in the exposed children than in the unexposed [14-16]. In Kenya, Gambia, Sierra Leone and in Burkina Faso, the risk of occurrence of anemia associated with malaria was respectively 0.9, 0, 7, 0.9 and 0.8 [10,17-19]. These results confirm the effect of iron supplementation in the prevention of anemia associated with malaria. Moreover, Okebe et al. confirm that positive effect of iron supplementation in children in malaria endemic areas [20].

The overall prevalence of anemia in the exposed before the intervention (hemoglobin level below11g/dl) was 93.3% but 76.7% in the unexposed. The difference was not statistically significant (p=0.1). After the intervention, this frequency in the exposed decreased from 93.3% to 63.3% (p=0.32) whereas in the unexposed it increased from 76.7% before the intervention to 80.0% (p=0.91). This fact probably means that even if there is no significant difference between the 2 groups before and after the intervention, many observations are to be mentioned first in the 2 groups taken as a whole. The average hemoglobin level has decreased. This decline was important enough in the group of children who had been exposed whereas there had been even an increase of anemia cases in the group of unexposed children (Table 2b). In the same connection, in comparing the two groups, taking into account the children with a hemoglobin level below 11 g/dl with those with a hemoglobin level above 11 g/dl, one notes that before supplementation, at the time when there was a decline of the number of children with a hemoglobin level below 11 g/dl at the end of supplementation, there was an increase of the hemoglobin level of those with hemoglobin level higher or equal to 11 g/dl (p=0.04). In the group of the children who were not exposed, one notes an increase of the number of children with hemoglobin level below 11 g/dl and a decline of those with hemoglobin level above 11 g/dl. In addition, in the group of children who had been exposed and who had hemoglobin level higher or equal to 11 g/dl, these different observations show that the intervention implied a significant improvement of the hemoglobin level (p=0.01). This fact suggests that even in the context where this difference before and after the intervention in each of the groups was not significant, it is important to help infants come through this situation of exaggeration of the importance of anemia during the period of exposure to multiple infesting bites of the female anopheles. Our results could be justified not only by the size of the two groups which is weak but also by the dosage of the medicine used (2 mg/kg/day) and the duration of supplementation which would had been long but shortened due to time constraints. Moreover, taking into account anemia frequency, before and after the intervention, it was noted that it declined by 30.0% in the group of the exposed whereas it increased by 3.3% in the group of the unexposed. This difference confirms the positive effect of iron supplementation in infants in the tropical areas (Table 2b).

The community-based approach of prevention of anemia associated with child malaria by means of iron supplementation by mothers, proved to be efficient for, after the two months of supplementation, anemia prevalence decreased from 93.3% to 63.3% in the group of the exposed.

Before supplementation, anemia was microcytic in 66.7% of the exposed children for 63.3% in the unexposed, it was hypochromic in 76.7% of the exposed children for 6.7% of the unexposed children. After supplementation, prevalence of microcytic anemia decreased to 6.7% in the exposed children for 63.3% in the unexposed children, hypochromic anemia was present in 6.7% of the unexposed for 3.3% in the exposed. These results may be based on the presence of nutritional deficiency anemia in these children. As a matter of fact, the surveys performed by CDC -Atlanta in 163 villages and 41 urban areas in Togo suggested that the etiology of anemia in children in the rural areas would be a combination of an insufficient iron intake, malaria and blood spoliation by intestinal parasites [21]. Although, the difference between the two groups was not statistically significant, all the same this supplementation enabled to improve the biological parameters of anemia in the group of supplemented children. In addition to this remark, the improvement of these biological parameters remains a strong and convincing reason in support of this supplementation (Table 5). These facts are in support of a possibility of iron supplementation in order to improve the iron supplementation status of these children in the contrary to WHO guidelines who contraindicate iron supply in such children [22] especially in rural settings. The same conclusion has been drawn by Okebe et al. in malaria endemic areas [20].

Among the socio-demographic factors, the mother's educational background and religion influence anemia in children in a significant way, respectively (p=0.002 and 0.0007). This can be understood as regard mother's educational background. For the less a mother is educated the less she can follow advices on the prevention of anemia and get rid of taboos and food prohibitions. The risk of having anemia was estimated to 4.3 for the child whose mother is not educated compared with the one whose mother was educated. But regarding occupation, the only possible reason is that the mother's profession and tasks did not probably enable them to take adequately care of their children. One could also think that through their profession, their incomes would be the reason. However, the incomes do not always reveal the socio-economic condition, particularly in rural areas where all the sources of income are not often disclosed. The risks encountered in this research work was respectively 1.4 times, 1.2 and 1.4 for the children of farmer mothers, housewives and others compared with the ones whose mothers were herders.

Nevertheless, contrary to other works in which iron supplementation caused side effects or infectious symptoms, in our context supplementation did not cause side effects. Infection cases were noted as much in the group of the exposed to supplementation as in the group of the unexposed to supplementation. But, it is worth noting that based on these results, it is important to implement this supplementation in a context where children are not exposed to infections or not at risk. These results were confirmed by Okebe et al. who showed in their study that iron with antimalarial treatment significantly reduced malaria and iron alone or with antimalaria treatment does not increase the risk of clinical malaria or death when

	Supplementation (+)	Supplementation (-)	RR $IC_{95\%}$	p
Children's age				**0.39****
6-12	3	2	1	
12-36	19	15	1.1 [0.5-2.0]	
36-59	8	13	1.6 [0.6-3.9]	
Children's sex				**0.42****
Female	17	20	1.2 [0.7-2.0]	
Male	13	10	1	
Ethnic group				**0.39****
Bariba	19	14	1	
Dendi	3	7	1.9 [0.7-5.2]	
Fulani	5	4	1.1 [0.5-2.0]	
Other	3	5	1.5 [0.6-3.9]	
Mother's religion				**0.52****
Muslim	22	18	1	
Christian	7	11	1.4 [0,7-2.7]	
Traditional	1	1	1.1 [0,3-4.5]	
Mother's educational Background				**0.37****
None	20	24	1.3 [0.8-2.2]	
Primary	9	6	1	
Secondary	1	0	0.6 [0.4-0.9]	
Mother's civil status				**1****
Married	25	25	1	
In Cohabitation	5	5	1	
**Insignificant difference				

Table 1: Distribution of the two groups of the sample following the characteristics of mothers and child minding women.

	Supplementation (+)	Supplementation (-)	RR	p
Hemoglobin level < 11 g/dl				0.3**
Before supplementation	28	23	1	
After supplementation	19	24	1.24 [0.82 –1.89]	
Hemoglobin level ≥ 11 g/dl				0.003*
Before supplementation	2	7	1	
After supplementation	11	6	0.34 [0.10-1.22]	
Malaria				0.1**
Yes	16	22	0.7 [0.5-1.1]	
No	14	8	1	
Anemia associated with malaria				0.0091*
Yes	12	22	2 [1.1-3.0]	
No	18	8	1	
*Significant difference; ** Insignificant difference				

Table 2a: Distribution of children according to their exposure status and evolution of anemia, malaria and anemia associated with malaria.

regular malaria surveillance and treatment services are provided [20].

On the other hand, although iron has a beneficial effect for the child in the prevention of anemia, it however exposes children to infections. For this reason, in this work, the incidence of bronchial pneumonia was higher in the exposed than in the unexposed (however the difference was insignificant p=0.11). In a study carried

	Exposed to Iron Supplementation (n= 30)	Non exposed to Iron Supplementation (n= 30)	p value
Before Supplementation (g/dl)			
Mean hemoglobin value + SD	10.14 ± 0.90	10.45 ± 0.59	0.12
Minimum-Maximum	8.6-12.6	9.4-11.7	
After Supplementation (g/dl)			
Mean hemoglobin value + SD	10,62 ± 1,10	9,57 ± 1,43	0,00232
Min-Max	8.5-12.9	5.5-12.4	

Table 2b: Evolution of mean hemoglobin value in the two groups before and after iron supplementation.

	Anemia		RR $IC_{95\%}$	P
	Yes	No		
Educational Background				
None	17 (85.0)	3 (15.0)	1	0.0009*
Primary	2 (22.2)	7 (77.8)	4.3 [1.2-14.9]	
Profession				
Farmer	7 (87.5)	1 (12.5)	1,4 [0.8-1.5]	0.007*
Herder	1 (100.0)	0 (0.0)	1	
Trader	0 (0.0)	4 (100.0)	-	
Craftwoman	0 (0.0)	1 (100.0)	-	
Housewife	10 (83.3)	2 (16.7)	1.2 [0.9-1.5]	
Other	1 (25.0)	3 (75.0)	4.0 [0.7-21.8]	

Table 3: Relation between the mother's educational background and anemia in the children exposed to iron supplementation.

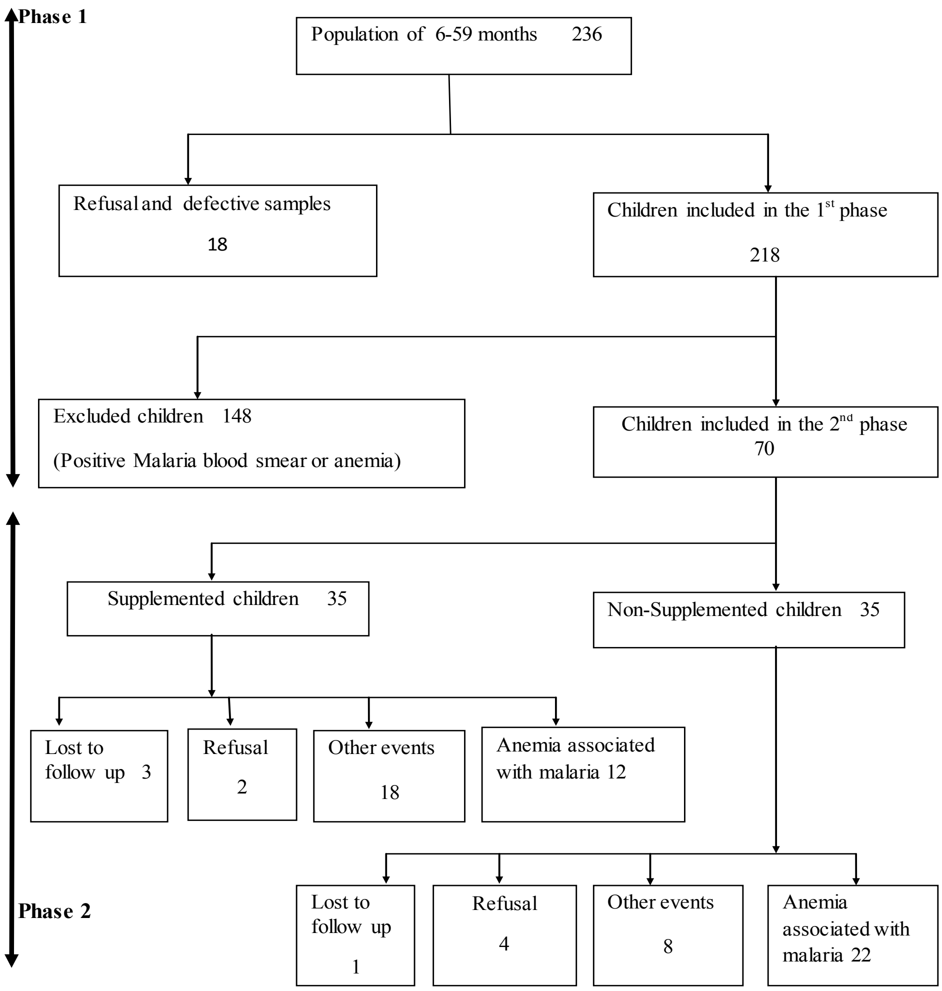
	Supplementation (+)	Supplementation (-)	RR	p
Anemia	19	24	0.84 [0.5-1.41]	0.51**
Malaria	16	22	0.8 [0.45-1.38]	0.39**
Other pathologies	7	3	2.19 [0.59-8.12]	0.18**
** Insignificant difference				

Table 4: Distribution of the children based on clinical factors.

	Before Supplementation	After Supplementation	RR	p
Supplemented children				
MCHC				1.4 10-6*
Hypochromic	23	2	4.05 [1.86-8.82]	
Normochromic	5	17	1	
MCV				4 10-5*
Microcytic	20	2	2.84 [1.58-5.11]	
Normocytic	8	17	1	
Non-Supplemented children				
MCHC				0.61**
Hypochromic	2	1	1.4 [0.59-3.29]	
Normochromic	21	23	1	
MCV				2.28 10-5*
Microcytic	19	5	4.55 [1.82-11.35]	
Normocytic	4	19	1	

*Significant difference; **Insignificant difference
MCHC: Mean Corpuscular Hemoglobin Concentration
MCV: Mean Corpuscular Volume
RR: Relative Risk

Table 5: Distribution of the children based on paraclinical factors before and after supplementation.



Graph 1: Flow chart of included children into the study on iron supplementation of infants in Bakperou (Parakou) in 2013. Eventually 30 children had been followed up at the beginning of the supplementation till the end in each of the two groups instead of the 35 initially recruited.

out by the WHO in Zanzibar, where malaria transmission by *Plasmodium falciparum* is stable, perennial and intense, the systematic administration of iron supplements plus folic acid with or without zinc provoked an increase of the frequency of serious adverse effects in children in terms of morbidity and mortality [23]. According to a similar sub-study, the adverse effects appear in children who were not iron deficient before taking supplements [23]. This fact suggests that supplementation should be implemented by meeting two conditions: on the one hand, children should be exposed if they experience the first signs of deficiency, and on the other hand this supplementation should be implemented in conditions where the child is not exposed to infections. According to scientific data, it is also known that iron given as supplementation or as treatment in an infected subject did not benefit to the latter but rather strengthened the inflammatory reactions and fostered the growth of the existing germ for it is diverted through the lymphoreticular system [23]. Besides, an inflammation that is subsequent to infection causes considerable changes in the iron metabolism which, according to popular belief, mainly passes through hepcidin production, antimicrobial peptide produced by liver which plays a prominent role in the regulation of iron metabolism by regulating the release of iron reserves and its intestinal assimilation, by increasing iron absorption in case of deficiency and by reducing it for the reconstitution of the iron reserves in the adult [21]. It is also known that in the case of malaria, it is presently recommended to undertake an iron supplementation therapy if necessary, only after final treatment of ongoing malaria because of risk of interactions between the antifolic antimalarial drugs and the supplements containing folic acid [21,22]. In Nepal, the test did not reveal any difference in the mortality and in the incidence of the current infections between the children taking iron and folic acid with or without zinc and those who took only zinc or a placebo [23] (Graph 1).

Conclusion

The issue of iron supplementation of infants and children in all the areas of the world remains a controversial topic for results have never been unequivocal. However in this research work, iron supplementation at a ratio of 2 mg/kg/day during 2 months allowed to reduce significantly the incidence of anemia associated with malaria. This supplementation also demonstrated that the average hemoglobin level declined in the two child groups, but at a level much more important in the group of the unexposed than in the one of the exposed. In fact, the study shows that the incidence of anemia associated with malaria was two times higher in the children who had not received an iron supplementation than in those who received an iron supplementation. It enabled to get rid of anemia in 32% of the children and to increase the average rate from 10.1 g/dl to10.8 gdl.

Moreover, this work allowed noting that the biological parameters (MCHC, MCV) substantially improved with supplementation (2.7 times) and that it is useful and beneficial to prevent anemia (2 times in the children presenting a hemoglobin level higher or equal to 11 g/dl) in villages where health facilities does not exist. The incidence of anemia associated with malaria was two times higher in the non-supplemented children than in the supplemented ones (p=0.009). The mother's educational background and profession would influence the effect of supplementation and no case of iron intolerance was observed in the children.

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