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Research Article

Iron levels and Associated Factors Among Preterm Delivered Infants in Five Selected Health Facilities in Mwanza Region, Northwestern Tanzania

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Abstract

Background: It is estimated that, in Tanzania 11percent of babies are born prematurely each year. Preterm delivered infants are more prone to iron deficiency because most of mother to child iron transfer occurs in the third trimester. *Methods*: This was a hospital based cross sectional study, conducted in five selected health facilities in Mwanza city. Three hundred and fifty preterm delivered infants aged 6 to 30 weeks were included in the study. Participants' information was obtained by using a pre-tested structured questionnaire. To determine body iron level, blood was collected to measure serum ferritin, full blood picture and C reactive protein. *Results*: In every 100 infants, 20 had low iron levels, 1 had latent iron deficiency, 3 had iron deficiency and 9 had iron deficiency anemia. Increase in infant's age and complementary feeding with cow's milk were significantly associated with iron deficiency anemia. In addition, hemoglobin level and mean corpuscular volume in combination is not a good alternative of serum ferritin in diagnosing low iron. *Recommendations*: Food fortification with iron and iron supplementation among preterm delivered infants are needed to prevent iron deficiency among these infants. Further studies to determine why older preterm delivered infants are more prone to iron deficiency anemia including type of food they eat are needed. Hemoglobin level and mean corpuscular volume can be used to rule out those without low iron but not to diagnose those with low iron level.

Keywords

Iron Levels, Hemoglobin Levels, Infants, Preterm Birth

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1. Introduction

Preterm birth is among the leading causes of neonatal mortality and the most common reason for neonatal hospitalization [1, 2]. Worldwide, preterm deliveries are estimated to be 15 million in each year that is 11% in a year which is equivalent to more than 1 in 10 babies [2]. In Tanzania, preterm deliveries are approximately 11.4% of all live births in a year [2]. In 2015, Tanzania was the 12th country with high number of preterm deliveries worldwide [2]. Preterm delivered infants face deficit of iron, which is an important micronutrient in many metabolic activities in the body [3-8]. Iron deficit in infants is physiological due to their rapid growth which leads to rapid increase in blood volume and muscle size [9]. This physiological iron deficit is more severe in preterm delivered infants and may lead to iron deficiency anemia the severe form of low iron level [9]. In preterm delivered infants the iron deficiency anemia occurs earlier in the first six months of the infants' period as compared to term delivered infants whom manifest during the second six months of infancy [9, 10]. Low body iron levels in these infants are made worse by different factors such as low maternal iron level, maternal bleeding and maternal illnesses such as hypertension and diabetes [8, 9, 11]. Preterm delivered infants' iron store can be improved by early iron supplementation and regular iron levels monitoring [9-13]. In Indonesia, which is a fifth country with high number of preterm deliveries worldwide, a study done by Puspitasari *et al* 2016 showed the prevalence of iron deficiency in preterm infants was 10% [14]. A study done by Kasasa *et al* in 2011 in Dar es Salaam, Tanzania on babies born with low birth weight showed that 34.1% had iron deficiency [5]. The iron levels and factors associated with iron deficiency anemia on preterm delivered infants were not well known in Tanzania, including Mwanza City, since there was no current study conducted before. This made it difficult in fund allocation and intervention planning for factors associated with iron deficiency anemia among preterm delivered infants. Therefore, this study aimed at identification of the magnitude, severity of low iron levels and areas which need improvement during management of preterm delivered infants for the improvement of iron levels leading to better growth and development.

2. Material and Methods

2.1. Study Design

This was a hospital based cross sectional study.

2.2. Study Area and Setting

The study was conducted in five selected health facilities of Mwanza Region, including Makongoro Health Center (MHC), Bugando Medical Center (BMC), Buzuruga health center, Nyamagana Hospital and Sengerema District Hospital.

2.3. Sampling Strategy and Sample Size

Convenient sampling method was used to choose five health facilities to conduct this study. Bugando medical center preterm delivered infants' clinic was chosen because of having high number of preterm delivered infants being managed there. Buzuruga health center, Makongoro health center and Nyamagana hospitals' RCH clinics were chosen because they have high number of under five years old children attendance. With high number of less than five years old children's attendance the possibility of getting desired population is increased. In addition, they are located near to Bugando medical center; this makes data collection activity manageable. Sengerema district hospital's RCH and preterm delivered infants' clinics were chosen because of high number of under five years old children and preterm delivered infants' attendance in the district respectively.

All preterm delivered infants aged 6 to 30 weeks who attended Makongoro Health Center RCH clinic, Bugando Medical Center preterm delivered infants' pediatrics clinic, Buzuruga Health Center RCH clinic, Nyamagana Hospital RCH clinic and Sengerema District Hospital premature and RCH clinics during study period who qualified were serially enrolled until the desired sample size of 350 was reached.

2.4. Data Collection

Parents/ guardians of the qualified preterm delivered infants were given information about the study, and then a written and verbal informed consent was sought from them. Infants' information was collected from the parents/ guardians by using a pretested structured questionnaire. Physical examination was done to all infants who were seen. To determine body iron level, blood samples were collected from all participants for measuring FBP, CRP and serum ferritin level.

2.5. Data Analysis

Data collected from questionnaire then transferred into the computer using Microsoft Excel 2007, Data were cleaned and analyzed using STATA software version 13. Continuous data was summarized using mean with standard deviation. Categorical data was summarized using proportion (percent), continuous data was summarized by using median with interquartile range. To determine the factors associated with iron deficiency anemia we performed a univariate logistic regression followed by multivariate logistic regression models. Odds ratios with their respective 95% confidence intervals were noted. A factor with 95% confidence interval that does not include 1.0 has been considered statistically significant. To all analyses, the p value less than 0.05 has been considered statistically significant. Specific objective number 4 was analyzed by using two by two contingency table.

2.6. Ethical Considerations

Ethical clearance and approval were sought from Joint CUHAS-BMC research ethics and Review committee. Permission to conduct the study was obtained from Makongoro Health Center, Buzuruga Health center, Nyamagana Hospital and Sengerema Hospitals' Administrations. Parents/guardians/caretakers were requested to sign a consent form for their willingness to participate in the study and for illiterate parents or guardians, they were asked to thumbprint. Children were treated according to the Health facility's guidelines.

3. Results

3.1. Distribution of Socio-Demographic Data Among Preterm Delivered Infants

A total of 350 preterm delivered infants were enrolled in the study. Their median age was 11 [IQR 6-22] weeks. Males were 174 (49.7%) and females were 176 (50.3%). Participants from Makongoro health center were 66 (18.9%), Bugando Medical Center ware 135 (38.6%), Buzuruga Health Center were 33 (9.4%), Nyamagana Hospital were 55 (15.7%) and Sengerema District Hospital were 61 (17.4%). Almost all infants (99.4%) were taken care by their mothers. Table 1 summarizes social-demographic data among preterm delivered infants.

Table 1. *Social Demographic and characteristics data of the preterm delivered infants.*

Variable	Number (n)	Percent (%)
Health facility		
Makongoro Health Center	66	18.9
Bugando Medical Center	135	38.6
Buzuruga Health Center	33	9.4
Nyamagana Hospital	55	15.7
Sengerema District Hospital	61	17.4
Age categories in weeks		
6 – 12 weeks	192	54.9
13 – 23 weeks	76	21.7
24 – 30 weeks	82	23.4
Sex		
Male	174	49.7
Female	176	50.3
Care taker		
Mother	348	99.4
Guardian	2	0.6
Care taker's age		
15 – 25 years	170	48.6
26 – 35 years	154	44.0
>35 years	26	7.4
Care taker's education level		
None	18	5.1
Primary	208	59.4
Secondary	107	30.6
College/university	17	4.9
Care taker's employment status		
Employed	254	72.6
Unemployed	96	27.4

3.2. Clinical Characteristics of the Preterm Delivered Infants

Out of 350 preterm delivered infants, 277 (79.1%) were born with a birth weight of < 2.5 kg but ≥1.5 kg and 98 (28%) had malnutrition. There were 28 (8.0%) infants with a history of receiving blood transfusion and 16 (4.6%) received iron supplements at least once. One infant (0.3%) had difficulty in breathing. Table 2 summarizes clinical characteristics of the preterm delivered infants.

Table 2. *Clinical characteristics of preterm delivered infants aged 6weeks 30weeks.*

Variable	Number (n)	Percentage (%)
Birth weight		
<1.5 Kg	73.0	20.9
≥1.5 to 2.49 Kg	277	79.1
Gestation status		
Single tone	294	84.0
Twins	53	15.1
Triplets	3	0.9
Using iron supplements		
Yes	16	4.6
No	344	95.4
Received blood transfusion		

Variable	Number (n)	Percentage (%)
Yes	28	8.0
No	322	92.0
Nutritional status		
Normal	209	59.7
Malnutrition	98	28.0
Undetermined	43	12.3
Palmar pallor		
Yes	45	12.9
No	305	87.1
Difficulty in breathing		
Yes	1	0.3
No	349	99.7
Presence of edema		
Yes	0	0.0
No	350	100.0
Hemoglobin level (g/dl)		
4.9 – 10.4 (low)	210	60.0
10.5 – 14.0 (normal)	120	34.3
14.1 – 19.5 (high)	20	5.7
Serum Ferritin level (ug/l)		
0 – 11.9 (low)	66	18.8
12 – 29.9 (normal)	79	22.6
30 – 580 (high)	205	58.6
Mean corpuscular volume (fl)		
38.4 – 71.9 (low)	101	28.9
72 – 88 (normal)	137	39.1
88.1 – 128 (high)	112	32.0
CRP levels (mg/l)		
0 – 10 (normal)	348	99.4
10.1 – 17 (high)	2	0.6

3.3. The Prevalence of Low Iron Levels Among Preterm Delivered Infants

Of 350 preterm delivered infants, there were 66 (19.0%) with low iron levels (low serum ferritin), 5 (1.4%) with latent iron deficiency, 12 (3.4%) with iron deficiency and 31 (8.9%) with iron deficiency anemia. Figure 1 summarizes the prevalence of low iron levels among preterm delivered infants.

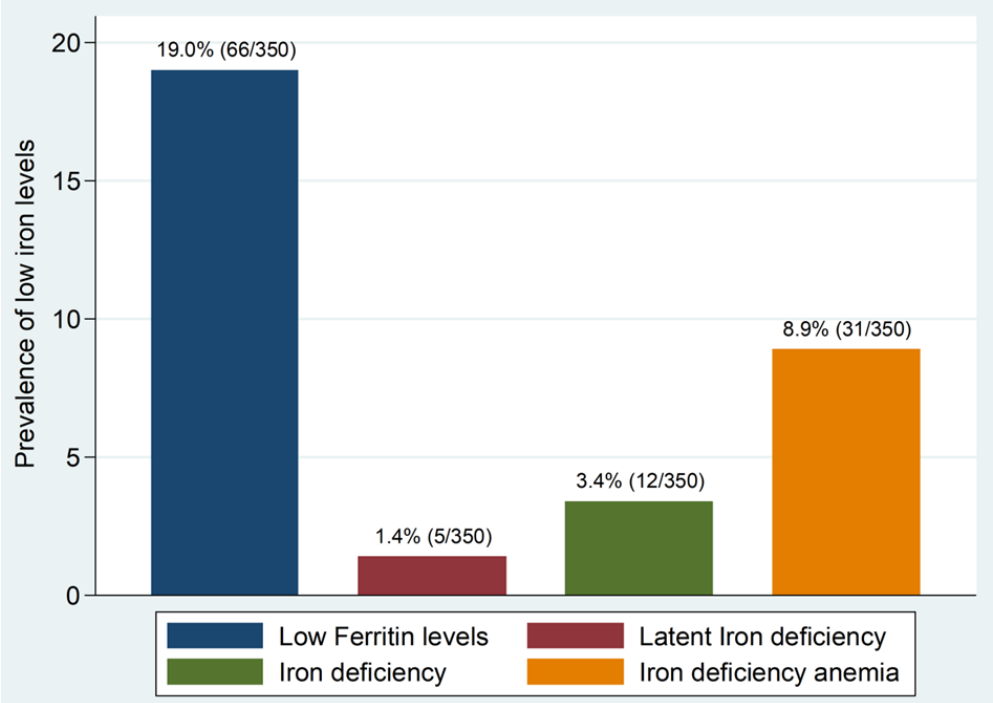

Figure 1. *Prevalence of low iron levels among preterm delivered infants.*

3.4. Factors Associated with Iron Deficiency Anemia Among Preterm Delivered Infants

On determination of factors associated with iron deficiency anemia, univariate analysis showed that, iron deficiency anemia is significantly associated with increasing infant's age (OR 12, 95% CI, with p value of < 0.001), starting complementary feeding at the age of twelve weeks and above (OR 8.5, 95% CI and p value of < 0,001), complementary feeding above 24 weeks (OR 5.0, 95% CI and p value of 0.002), complementary feeding with cow's milk (OR 14, 95% CI and p value of < 0.001), and complementary feeding with porridge (OR 5.5, CI 95%, p value of < 0.001). Following multivariate logistic regression analysis, the factors associated with iron deficiency anemia were increasing in the infants' age (OR of 8, 95% CI, p value of 0.007) and complementary feeding with cows' milk (OR 8.8, 95% CI, p value of <0.001). Table 3 summarizes factors associated with iron deficiency anemia among preterm delivered infants.

Table 3. *Factors associated with iron deficiency anemia among preterm delivered infants.*

Patient characteristics	Iron Deficiency Anemia		Univariate		Multivariate	
	Yes	No				
	n (%)	n (%)	OR [95%CI]	p-value	OR [95%CI]	p-value
Age in weeks						
6 – 12	5 (2.6)	187 (97.4)	1.0			
13 – 23	6 (7.9)	70 (92.1)	3.2 [0.9-10.8]	0.061	3.2 [0.8-12.4]	0.092
24 – 30	20 (24.3)	62 (75.6)	12 [4.3-33.5]	<0.001	8 [1.7-36.8]	0.007
Nutritional status						
Normal	19 (9.1)	190 (90.9)	1.0			
Malnutrition	11 (11.2)	87 (88.8)	1.3 [0.6-2.8]	0.558	0.8 [0.3-2.0]	0.565
Undetermined	1 (2.3)	42 (97.7)	0.2 [0.0-1.8]	0.168	0.8 [0.8-7.5]	0.819
Age started complementary feeding						
Still on exclusive breast feeding	10 (4.3)	225 (95.7)	1.0			
Less than 12weeks	2 (6.5)	29 (93.5)	1.6 [0.3-7.4]	0.583	0.3 [0.0-2.1]	0.224
From 12 -24weeks	11 (27.5)	29 (72.5)	8.5 [3.3-21.8]	<0.001	1.2 [0.3-5.4]	0.847
Above 24weeks	8 (18.2)	36 (81.8)	5.0 [1.9-13.5]	0.002	0.5 [0.1-2.6]	0.380
Formula milk						
No	29 (8.9)	298 (91.1)	1.0			
Yes	2 (8.7)	21 (91.3)	1.0 [0.2-4.4]	0.978		
Cow's milk						
No	20 (6.1)	306 (93.9)	1.0			
Yes	11 (47.8)	12 (52.2)	14.0 [5.5-35.7]	<0.001	8.8 [2.8-27.7]	< 0.001
Goat's milk						
No	30 (8.6)	318 (91.4)	1.0			
Yes	1 (50.0)	1 (50.0)	10.6 [0.6-173.8]	0.098	5.8 [0.2-158.9]	0.298
Porridge and other carbohydrate foods						
No	12 (4.6)	248 (95.4)	1.0			
Yes	19 (21.1)	71 (78.9)	5.5 [2.6-11.9]	<0.001	2.6 [0.8-7.9]	0.096

3.5. Sensitivity and Specificity of Using Hemoglobin Level and MCV in Determining Iron Levels Among Participants

On comparing the sensitivity and the specificity of using Hb and MCV together in determining low iron levels versus using serum ferritin, it has been found that, the sensitivity and specificity of using MCV and Hb were 47% (31/66) and 84.1% (239/284) respectively of that which will found when serum ferritin is used. This means that, 47% of those who were identified by serum ferritin to have low iron levels were also identified to have low iron level by using Hb and MCV in combination. In addition, 84.1% of those identified not to have low iron level by serum ferritin were also identified not to have low iron levels by using Hb and MCV in combination. Table 4 summarizes the analysis of sensitivity and specificity of using Hb and MCV in determining low iron levels among preterm delivered infants.

Table 4. *A two by two contingency table for analysis of sensitivity and specificity of using MCV and Hb together compared to the usage of serum ferritin in diagnosing low iron level.*

	Ferritin deficiency		
	Yes	**No**	**Total**
MCV-Hb together	**n (%)**	**n (%)**	**n (%)**
Yes	31 (47.0)	45 (15.9)	76 (21.7)
No	35 (53.0)	239 (84.1)	274 (78.3)
Total	66 (100)	284 (100.0)	350 (100.0)

3.6. The Prevalence of Iron Deficiency Anemia Among Preterm Delivered Infants in Each Health Facility

Among the five health facilities where the study was done, Bugando medical center had significant higher prevalence of iron deficiency anemia among preterm delivered infants (16.3%) than other health facility. Table 5 summarizes the prevalence of iron deficiency anemia among preterm delivered infants in each health facility.

Table 5. *The prevalence of iron deficiency anemia among preterm delivered infants in each health facility.*

	Iron deficiency anemia			
Health facility	**Yes**	**No**	**Total**	**P – value**
	n (%)	**n (%)**		
Makongoro health center	4 (6.06)	62 (93.94)	66 (100%)	0.007
Bugando medical center	22 (16.30)	113 (83.70)	135 (100%)	
Buzuruga health center	1 (3.03)	32 (96.97)	33 (100%)	
Nyamagana district hospital	2 (3.64)	53 (96.36)	55 (100%)	
Sengerema district hospital	2 (3.28)	59 (96.72)	61 (100%)	

3.7. The Proportion of the Preterm Delivered Infants Who Received Iron Supplements in Each Health Facility

There were a low proportion of preterm delivered infants who received iron supplements even once in all five health facilities. The health facility with lowest proportion was Buzuruga health center (0%). Table 6 summarizes the proportion of the preterm delivered infants who received iron supplements in each health facility.

Table 6. The proportion of the preterm delivered infants who received iron supplements in each health facility.

	Iron supplements			
Health facility	**Yes**	**No**	**Total**	**P – value**
	n (%)	**n (%)**		
Makongoro health center	3 (4.55)	63 (95.45)	66 (100.00)	0.733
Bugando medical center	6 (4.44)	129 (95.56)	135 100.00)	
Buzuruga health center	0 (0.00)	33 (100.00)	33 (100.00)	
Nyamagana district hospital	3 (5.45)	52 (94.55)	55 (100.00)	
Sengerema district hospital	4 (6.56)	57 (93.44)	61 (100.00)	

3.8. Common Clinical Feature Associated with Iron Deficiency Anemia Among Preterm Delivered Infants

Among preterm delivered infants with iron deficiency anemia, it was found that palmar paloris significantly the most common presenting clinical feature (28.89%) compared to the other features (p value of < 0.001). Table 7 summarizes the common clinical feature associated with iron deficiency anemia among preterm delivered infants.

Table 7. Common clinical feature associated with iron deficiency anemia.

	Iron deficiency anemia			
Clinical sign	**Yes**	**No**	**Totaln (%)**	**p- value**
	n (%)	**n (%)**		
Palmar Palor				
Yes	13 (28.89)	32 (71.11)	45 (100%)	< 0.001
No	18 (5.90)	287 (94.10)	305 (100%)	
Difficulty in breathing				
Yes	0 (0.00)	1 (100)	1 (100)	0.911
No	31 (8.88)	318 (91.12)	349 (100)	
Gallop rhythm				
Yes	2 (40.00)	3 (60.00)	5 (100.00)	0.061
No	28 (8.16)	315 (91.84)	343 (100.00)	

4. Discussion

The median serum ferritin among preterm delivered infants

The median serum ferritin level was 44.4 [IQR 15.7 - 102] which is low. This may be explained by the fact that only 4.6% of the infants received iron supplements even once despite of WHO recommendation to give iron supplements to the preterm delivered infants up to the age of one year. It was also found out that even those who received blood transfusion due to severe anemia did not continue with iron supplements. This median is higher than what was found by Ferri*etal*in Brazil i.e. 22.6 [11.4 – 38.6] [16]. Difference between these findings could be due to the reasons that in this study, infants' serum ferritin level was checked at younger age (6 – 30 weeks chronological age) than in a Ferri *et al* study (at 12 months of corrected gestation age). Another reason is that most of the participants were very sick during their early neonatal period and a larger proportion received blood transfusion in Ferri*et*al study [16].

Prevalence of low iron levels among preterm delivered infants

In this study, it was found that, the prevalence of low iron level was 19%, and iron deficiency anemia was 8.4%, this is higher compared to10% and 6% of low iron level and iron deficiency anemia, respectively that was found in the study done in Indonesia by Puspitasari *et al* but lower than what was found in Tanzania (low iron level was 34.1%) by Kasasa *et al* and that done in Brazil by Ferri *et al* (low iron level was 48%). This difference in prevalence of low iron level between this study and the previous mentioned could be attributed by the infants' age and geographical area differences, 6 weeks up to 30 weeks in this study versus two months of age in Puspitasari *et al* study, one month up to 12 months in Kasasa *et al* study and infants at 12 months corrected age in Ferri *et al* study [5, 14, 16]. It can be explained by the reason that, as the infant grows especially when more rapid, the iron demand becomes more hence they are at an increased risk of developing low iron levels in their body [9]. Furthermore, the difference in prevalence with Puspitasari *et al* study could be due to the fact that 40% of infants were supplemented with iron compared to 4.6 % in this study and the sample size was very small (83 versus 350) [14]. Moreover, in Puspitasari *et al* study serum ferritin level cut off for normal value was 45ng/ml (45µg/l) which is very high versus 12µg/l with normal CRP or 30µg/l with high CRP. In addition, Hb cut off point of 9.8g/l versus 10.5g/dl used in this study this can reduce the number of infants with low iron level [14]. Not only that, but also in Puspitasari *et al* study they used other more biomarkers (Serum iron, total iron binding capacity, and trasferrin saturation) that were not used in this study [4]. In addition, the higher prevalence found in Kasasa *et al* study could be contributed by not considering the effect of inflammatory process on ferritin levels so the higher levels might be due to inflammation, as ferritin levels is one of the acute phase reactants [5, 15]. Not only that but also Kasasa *et al* study included infants delivered with low birth weight both term and preterm but in this study only preterm delivered infants were included [5]. Despite of WHO recommendation that preterm delivered infants are to be given iron supplements due to their susceptibility of having low iron levels, only 4.6% [6] had history of receiving iron supplements and 8% of infants had a history of blood transfusion. This proportion of infants who received blood is high. The reason for high proportion of anemia could be explained by the fact that, as infants are born prematurely they succumb lesser time for transplacental iron transfer hence more prone to iron deficiency anemia. However, in a study done by Ferri *et al* the proportion was much higher than our finding (59% versus 8%) [16]. This difference could be attributed by the fact that in Ferri *et al* study all the infants were born with very low birth weight (<1.5 kg) and most of them were very sick during their early neonatal period whereas in our study most of the infants were not very sick.

Factors associated with iron deficiency anemia among preterm delivered infants

Multivariate analysis showed that increase in infant's age is significantly associated with iron deficiency anemia (24.3%), this is similar to what was found in a study done in Nepal by Chandyo *et al* [17]. This could be due to the fact that as infant grows, iron demands increase, and preterm delivered infants have rapid growth [9]. Furthermore, complementary feeding with cow's milk has been significantly associated with iron deficiency anemia (47.8%). This is similar to what was found in a study done in Brazil by Ferri *et al* whereby the prevalence of iron deficiency anemia in infants receiving cow's milk at 6 months was 26.5% [16]. This could be due to the fact that cow's milk has low amount of iron as it is a case of breast milk but in addition it provides excess protein (has high amount of cassein which is not easily digestible than whey) and minerals that hinders iron absorption. Moreover, its intake is associated with fecal occult blood loss in infants aged < 12 months.

Sensitivity of using serum ferritin, Hb and MCV to surrogate detection of low iron levels among preterm delivered infants

This study revealed that, using MCV and Hb in combination as surrogate markers to estimate iron levels has a low sensitivity of 47% and the specificity of 84.1% compared to that found when using serum ferritin. Since the relationship of serum ferritin and body iron has been well established (1µg = 8 – 10 mg of body iron in adults) and it can therefore be used in assessment of iron in cases where bone marrow assessment is not possible as stated by Cook *et al,* 1982. This finding shows that using MCV together with Hb is a poor method of detecting low iron levels but it can be used to rule out those without low iron levels. This finding could be due to the fact that serum ferritin starts to detect the presence of low iron level at the stage of body iron store depletion but MCV and Hb starts to change as the stage of iron deficit advances, whereby functional iron (for RBC production) has tremendously decreased.

The prevalence of iron deficiency anemia among preterm delivered infants in each health facility

In this study it has been revealed that, Bugando Medical Center had significant higher prevalence of iron deficiency anemia among preterm delivered infants (16.3%) than other health facility that participated. This could be contributed by the fact that most of the preterm delivered infants with very low birth weight and who are unstable / very sick in lake zone area are sent to BMC for further management including blood transfusion (including those from other 4 health facilities that participated in this study). After their discharge they continue to attend BMC preterm delivered infants' clinic.

The Proportion of the preterm delivered infants that received iron supplements in each health facility

The proportion of preterm delivered infants who received iron supplements even once was found to be low in all five health facilities. The health facility with the lowest proportion was Buzuruga Health Center (0%). The main reasons in all health facilities is that, health care providers neither counseled the parents on the iron supplement use, its importance to the preterm delivered infants nor prescribed iron supplements to the infants.

Common clinical feature associated with iron deficiency anemia among preterm delivered infants

Among preterm delivered infants with iron deficiency anemia, it was found that palmar pallor is statistically significant the most common presenting clinical feature (28.89% versus 5.90%). This could be explained by the fact that other features like gallop rhythm, edema and difficulty in breathing occurs in more advanced stage of iron deficiency anemia.

5. Conclusion

The median serum ferritin was 44.4 [15.7–102] µg/l. In every 100 preterm delivered infants in this study, 20 had low iron level, 1 had latent iron deficiency, 3 had iron deficiency and 9 had iron deficiency anemia. Furthermore, the increase in infants' ages which is associated with increase in metabolic activities and hence increases in iron utilization was significantly associated with iron deficiency anemia. Not only that but also usage of cow's milk supplementation which has low iron as in case of breast milk in addition to poor bioavailability was found to be significantly associated with iron deficiency anemia. Using Hemoglobin and mean corpuscular volume in combination to surrogate detection of iron level has low sensitivity but high specificity, so they can be used in ruling out those without low iron level but cannot be used in detection of those with low iron level. In addition, there is very low proportion of preterm delivered infants that received iron supplements (4.6%) despite of an increase iron demand among these infants.

6. Recommendation

Preterm delivered infants are more likely to have low body iron, so iron supplementation as one of the means to improve body's iron levels for better growth and development should be encouraged among the health care providers and care givers. Monitoring preterm delivered infants' iron levels should be done at the age of four months, seven months and ten months so as to detect those with low body iron level earlier as iron deficiency develops progressively with increase in age. The combination of MCV and Hb should be used to rule out those without low iron level in screening activities but not for diagnosing low iron levels. Food fortification with iron should be done so as to reduce iron deficiency among preterm delivered infants as well as the whole society due to the fact that both breast milk and cows' milk have low iron which does not meet the infants' requirements as they continue to grow. Further studies to determine why older preterm delivered infants are more prone to iron deficiency anemia including type of food they are taking are needed. In addition, further studies with larger sample size and different settings to investigate iron levels and associated factors including maternal factors are warranted.

Abbreviations

BMC	Bugando Medical Centre
CUHAS	Catholic University of Health and Allied Sciences
MCV	Mean Corpuscular Volume
Hb	Hemoglobin
RBC	Red Blood Cell
CRP	C-reactive Protein
FBP	Full Blood Picture

Acknowledgments

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Declaration

Ethics Approval and Consent to Participate All methods were carried out in accordance with relevant guidelines and regulations, informed consent was obtained from all subjects' parents or their legal guardian(s). This study was approved by BMC/CUHAS ETHICS. Permission for conducting the research was granted by the Director of Bugando Medical Centre. The consent was also sought from the participants before recruitment.

Consent for Publication

All authors read the manuscript and approved it for Publication.

Author Contributions

Nakiete Samwel Machangu: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing

Neema Mathias Kayange: Conceptualization, Data curation, Investigation, Methodology, Supervision, Visualization, Writing – original draft

Respicious Christopher Bakalemwa: Conceptualization, Formal Analysis, Methodology, Supervision, Visualization, Writing – original draft

Benson Richard Kidenya: Conceptualization, Data curation, Formal Analysis, Methodology, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

Ndakibae Gabriel Mabega: Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing

Data Availability Statement

The database used and analyzed during the current study is available from the corresponding author and will available on request.

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Tanzania, RACH, The National Road Map Strategic Plan to Accelerate Reduction ofMaternal, Newborn and Child Deaths in Tanzania 2008 - 2015. Sanga C. et al, editor. Ministry of Health and Social Welfare, Tanzania. p. 6-7. http://www.who.int/pmnch/countries/tanzaniamapstrategic.pdf

[2] Blencowe H, Cousens S, Oestergaard MZ et al. National, regional, and worldwide estimatesof preterm birth rates in the year 2010 with time trends since 1990 for selected countries: asystematic analysis and implications. The Lancet. 2012; 379(9832): 2162-72. https://doi.org/10.1016/S0140-6736(12)60820-4

[3] Clardy S, Wang X, Zhao W et al. Acute and chronic effects of developmental irondeficiency on mRNA expression patterns in the brain. Oxidative Stress and Neuroprotection. 2006: 173-96.

[4] deUngria M, Rao R, Wobken JD et al. Perinatal iron deficiency decreases cytochrome coxidase (CytOx) activity in selected regions of neonatal rat brain. Pediatric research.2000; 48(2): 169-76.

[5] Kasasa A. Neurodevelopment of Low Birth Weight Born Infants in Relation to their IronStatus in Dar es salaam, Tanzania. 2011. http://dspace.muhas.ac.tz:8080/xmlui/handle/123456789/52

[6] Lozoff B, Georgieff MK, editors. Iron deficiency and brain development. Seminars inpediatric neurology; 2006: Elsevier. https://doi.org/10.1016/j.spen.2006.08.004

[7] Tran PV, Fretham SJ, Carlson ES et al. Long-term reduction of hippocampal brain-derivedneurotrophic factor activity after fetal-neonatal iron deficiency in adult rats. Pediatricresearch. 2009; 65: 493-8. https://doi.org/10.1203/PDR.0b013e31819d90a1

[8] Robert M. Kliegman et al. Nelson Textbook of Pediatrics, 20th ed. Philadephia, ElsevierInc. 2016. p 821-824.

[9] Strauss RG. Anaemia of prematurity: pathophysiology and treatment. Blood reviews.2010; 24(6): 221-5. https://doi.org/10.1016/j.blre.2010.08.001

[10] Olivares M, Llaguno S, Marin V et al. Iron status in low-birth-weight infants, small andappropriate for gestational age. A follow-up study. ActaPaediatrica. 1992; 81(10): 824-8. https://doi.org/10.1111/j.1651-2227.1992.tb12111.x

[11] Chockalingam UM, Murphy E, Ophoven JC et al. Cord transferrin and ferritin values innewborn infants at risk for prenatal uteroplacental insufficiency and chronic hypoxia. TheJournal of pediatrics. 1987; 111(2): 283-6. https://doi.org/10.1016/s0022-3476(87)80088-4

[12] AAP. Diagnosis and Prevention of Iron Deficiency and Iron-Deficiency Anemia in Infantsand Young Children (0 –3 Years of Age). Clinical Report. October, 2010 http://pediatrics.aappublications.org/content/pediatrics/early/2010/10/05/peds.20102576.full.pdf

[13] Lundström U, Siimes MA, Dallman PR. At what age does iron supplementation becomenecessary in low-birth-weight infants? The Journal of pediatrics. 1977; 91(6): 878-83. https://doi.org/10.1016/s0022-3476(77)80881-0

[14] Puspitasari HA, Windiastuti E, Hendarto A. Iron profiles of preterm infants at two monthsof chronological age. Paediatricaindonesiana. 2017; 56(5): 277-84. https://doi.org/10.14238/pi56.5.2016.277-84

[15] World Health Organization. Serum ferritin concentrations for the assessment of iron statusand iron deficiency in populations. Vitamin and Mineral Nutrition Information SystemGeneva: 2011 (WHO/NMH/NHD/MNM/11.2). http://www.who.int/vmnis/indicators/serum_ferritin.pdf

[16] Ferri C, Procianoy RS, Silveira RC. Prevalence and Risk Factors for Iron-Deficiency Anemia in Very-Low-Birth-Weight Preterm Infants at 1 Year of Corrected Age. Journal of Tropical Pediatrics. 2014; 60(1): 53-60. https://doi.org/10.1093/tropej/fmt077

[17] Chandyo RK, Henjum S, Ulak M et al. The prevalence of anemia and iron deficiency ismore common in breastfed infants than their mothers in Bhaktapur, Nepal. European Journal of Clinical Nutrition. 2015; 70: 456. https://doi.org/10.1038/ejcn.2015.199