ORIGINAL ARTICLE

Iron Deficiency and Iron Deficiency Anemia Among Children 3 to 59 Months of Age in Kinondoni Municipal, Dar es Salaam: A Facility-Based Cross-Sectional Study

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ABSTRACT

Background: Iron deficiency with subsequent iron deficiency anemia is the most common micronutrient disorder in children below 5 years of age worldwide. The developing countries bear more weight on the problem as the result of multifactorial factors including but not limited to recurrent infections such as malaria, helminths infestation, and inadequate food security. However, its magnitude in children living in Kinondoni Municipal in Dar es salaam is not well understood. Therefore, the aim of this study was to determine the prevalence of anemia and how it is contributed by the presence of iron deficiency among children between 3-59months of age in the above-mentioned setting.

Methods: A facility-based cross-section study was conducted among children 3-59months attending Reproductive and Child Health Services at Kairuki, Sinza Hospital, and Kambangwa dispensary. Children who met the criteria, their basic social demographic information, complete blood count and differentials as well as blood ferritin levels were collected to assess the level of anemia, erythrocytic indices, and iron deficiency. Data were analyzed using the Statistical Package of Social Sciences (SPSS version 22). The magnitude of anemia and iron deficiencies were presented in percentages, and the relationship between hemoglobin and blood ferritin was assessed using Spearman's correlation test for two continuous variables. The p-value of less or equal to 0.05 was considered statistically significant.

Results: A total of 350 children were recruited for the study, 255 Children (72.9%) were anemic. Children below 24 months of age were more anemic compared to the older age group ($X2 = 50$, $p <0.001$). Furthermore, anemia was significantly associated with low ferritin levels ($X2 = 65$, $p <0.001$). Iron deficiency was found in 156 (44.6%) participants while iron deficiency anemia (low MCV, low ferritin, and low hemoglobin) was found in 138 (39.4%) participants. However, among 255 participants with anemia, 147(65.3%) had iron deficiency. There was a significant positive correlation between hemoglobin and blood ferritin levels (Spearman's correlation coefficient = 0.6; $p<0.01$.

Conclusion: Prevalence of anemia was high among children and was highly associated with younger age and iron deficiency. To overcome this problem, appropriate interventions such as massive promotion of breastfeeding, appropriate complementary feeding, and ensuring food security are warranted.

INTRODUCTION

Anemia is defined as a quantitative or qualitative deficiency of hemoglobin, or reduction in the number or volume of red blood cells with subsequent reduction in oxygen carrying capacity of blood to meet the body's physiological needs. For children below 5 years of age, it is defined as hemoglobin below 11g/dl.[1] According to the 2019 World Health Organization (WHO) data on anemia, globally up to 39.8% of children under-fives were anemic with the African region recording up to 60.2% of children of the same age with anemia.[2] The most common causes of anemia in low resources settings are nutritional deficiency (iron, vitamin B12, and folic acid); infections such as malaria, hemoglobinopathies, and hookworm infestation.[3,4] Iron deficiency anemia is the most common type of anemia in children, especially in developing countries where nutritional deficiency and hookworm infestation are rampant.[3–5] The diagnosis of iron deficiency anemia is made in combination of hemoglobin level being below 11g/dl and blood ferritin less than 12µg/L while isolated iron deficiency is confirmed when blood ferritin is less than 12µg/L with normal hemoglobin. [1] Iron is an instrumental element in red blood cell formation (erythropoiesis). It is an essential component of hemoglobin and oxygen-carrying molecule in the red blood cells by supplying ferrous ions for heme ring formation that links four polypeptide chains in the hemoglobin structure.[6] Moreover, iron plays a vital role in enzymatic functions during energy metabolism, neurotransmission, soft tissue formation, and immune system modulation.[7,8]

Children are more vulnerable to iron deficiency and iron-deficiency anemia due to the high demand for growth and development. Chronic deprivation of iron leads to iron depletion with subsequent low hemoglobin levels (anemia). Iron deficiency has detrimental effect on children such as poor weight gain; language, behavior, psychomotor skills, and cognitive impairment.[9,10] It has been proved that prolonged iron deficiency in early life, may lead to permanent disability especially in cognitive ability which cannot be re-corrected by iron supplementation.[7,8] If not well addressed, it will continue to be a stumbling block to children's wellbeing and survival. Unfortunately, the signs and symptoms of iron deficiency in children are not specific and start gradually over time which makes early detection and management a challenge; hence, prevention is the best intervention.

To prevent iron deficiency and iron-deficiency anemia in children, it is recommended to exclusively breastfeed for the first 4-6 months and then initiate infant feeding using iron-containing complementary foods such as green leafy vegetables, legumes, meat, poultry, and seafoods.[11] Children below 5-years of age should take around 10gm/day as a daily dietary requirement for metabolic demand and body iron stores.[11] In settings where the prevalence of anemia is to equal or more than 40%, WHO recommends daily iron supplementation in children aged 24-59 months as a preventive strategy. [12]

Despite the public health burden of iron deficiency and iron-deficiency anaemia worldwide, there is limited data on the magnitude in different settings in Tanzania. Therefore, this study aimed to determine the magnitude of iron deficiency and iron deficiency anemia among children 3 to 59 months of age in Kinondoni municipal in Dar es Salaam. Findings from this study may provide more insight on the problem in urban areas such as Dar es Salaam and inform on more appropriate mitigation strategies.

METHODS

Study Area

This study was conducted in Kinondoni Municipality in Dar es Salaam metropolitan city. Kinondoni is among 5 administrative municipals on 321 square meters of land. In the 2012 national census, Kinondoni had around 930,000 inhabitants with a steady population growth rate of 5% per annum.[13] Being in the urban area, the economic activities range from being employed in formal and informal sectors, and large to small scale businesses.

Study Sites

This study was conducted at Kambangwa Dispensary, Kairuki and Sinza Hospitals which are in Kinondoni Municipal. Participants were healthy children between 3-59 months who were attending Reproductive and Child Health (RCH) clinics. These facilities were randomly selected from the list of health care facilities in Kinondoni Municipal.

Study Design

This was cross-sectional descriptive study among children 3-59 months of age attending RCH clinics for six months from May 2016 to November 2016.

Sample Size Determination

The sample size was calculated using Cochran's formula for cross-sectional studies[14] by using a selected critical value at 95% confidence interval (1.96), desired level of precision of 0.05, and an estimated prevalence of iron deficiency anemia at 35% from Tanzania Demographic and Health Survey 2010.[15] Therefore, a total of al 350 children were recruited into our study.

Inclusion and Exclusion Criteria

Children attending Reproductive and Child Health Clinic (RCH) at Kairuki, Kambangwa, and Sinza Hospitals aged between 3 months and 59 months were eligible for participation. Children with a known genetic or congenital condition that can cause anaemia such as active haemorrhage; bleeding disorders or hemoglobinopathies; history of blood transfusion and/or surgery within three months before screening date; those with febrile illness, known history of chronic infections and other inflammatory conditions were excluded from the study.

Ethical Issues

Ethical clearance was obtained from the Hubert Kairuki Memorial University (HKMU) Research Ethics Committee before this study was conducted. The permission to conduct the study was obtained from Kinondoni Municipal health administration authorities as well as from respective hospitals. An informed consent was obtained from the parents/caretakers of participants before enrolment. Confidentiality was ensured for all individuals who participated in the study. No personal identifiers were used in the data collection tools. To minimize the risks, blood collection was performed by experienced personnel using routine procedures and observing aseptic techniques. Children below 3 months of age were excluded to minimize pain and discomfort because their visits coincide with injectable vaccinations. Participants who were found to be anaemic were managed according to Tanzania National guidelines.[16]

Recruitment Procedures

All non-ill children who were attending at Reproductive and Child Health Clinic (RCH) at Kairuki, Kambangwa (Mwananyamala), and Sinza Hospitals during the day of an interview were eligible to participate in this study. Participants were screened for eligibility, and those who met the inclusion criteria, the informed consent was sought from their parents/caregivers to participate in the study. For those whose parents consented, they were recruited sequentially until the required sample size was obtained.

Data collection

Socio-Demographic Information

Sociodemographic information was collected from the participants and their parents/caretakers using a pre-designed Case Report Form (CRF). Information regarding patients' age, sex, residence, birth weight, natal history of prematurity, breastfeeding practices, age at introduction of other types of food, and types of complementary food in the first year of life, dietary recall were obtained from parents/guardians. Additional information that was taken includes marital status, family history of Sickle cell disease, and history of chronic illnesses g. HIV/AIDS.

Parents/guardians' occupation, information about family size, and education level of the mother were also collected. Moreover, a clinical examination of the participants was performed including anthropometric measurements which were conducted as per WHO standard guidelines.[17]

Anthropometric Measurements

The children under 24 months of age were weighed with non-clothes at the enrolment site using a 25kg hanging Salter weigh scale (SECA, Hamburg, German), while those above 24 months of age were weighed while standing on the Salter digital floor scale. Height was measured using a standard wooden stadiometer. Height for children above 24 months was taken while standing with bare feet while the length for those below 24 months was measured while lying flat on the measuring board with an assistant supporting the legs on the measuring board to ensure that the child was lying flat. Measurements were recorded to the nearest 0.1cm. The nutrition status of participants was determined as mild, moderate, or severe according to the z-score of the weight for height on the WHO reference charts for age and sex.[18]

Full Blood Count and Blood Ferritin Determination

Two milliliters of venous blood sample from each study participant were collected and transported for analysis at Hubert Kairuki Memorial University Clinical Research Laboratory in line with the International Council for Standardization in Hematology (ICSH) using the point of care standard operating procedures explained elsewhere.[19] A complete Blood Count (CBC) was performed using an automated hematology analyzer (Beckman-Coulter, Model Act 10, Brea, CA, USA,). Anemia status was determined by hemoglobin values, and severity of anemia was determined using WHO standards for children whereby normal values should be ≥11g/dl, mild anemia 10-10.9g/dl, moderate anemia 7-7.9g/dl, and severe anemia <7g/dl[2]. Serum ferritin levels as a marker of iron deficiency were determined using the electrochemiluminescence method[20] (Maglumi -62000, Biomedical Engineering Co. Ltd, Shenzhen, China). Blood ferritin levels less than 12µg/L were classified as low (iron deficiency) while those with anemia, MCV less than 80fl on CBC, and ferritin level less than 12µg/L were classified as iron deficiency anemia.

Data Analysis

Data was analyzed using Statistical Package for Social Sciences (SPSS) version 20.0 (IBM Corp., Armonk, NY, USA). Association between independent variables and presence of anemia was assessed using the Chi-square test or Fisher's exact test whenever appropriate. The relationship between blood hemoglobin and ferritin levels was determined using Spearman's test. A cut-off point for statistical significance of analyses (*p*-value) was set at less or equal to 0.05.

RESULTS

A total of 350 children were enrolled in the study. Males were 193 (55.1%) while females were 157 (44.9%). The mean age for participants was 17.3±11 months. Other Baseline characteristics of participants and parents are indicated in Table 1.

Prevalence of Anemia

Anemia was present in most participants, whereby 255 participants (72.9%) were anemic. Severe anemia was present in 2 (0.6%) of the study participants, while the rest had either mild or moderate anemia (Table 2). Children under 24 months were more affected whereby 218 out of 267 (81.6%) children below 24 months were anemic; $X^2 = 50$, $p < .001$ (Table 3). Moreover, anemia was associated with low ferritin levels; $\mathbf{X^2} = 65$, $p < 0.001$ (Table 3). Furthermore, among 225 participants with anemia, 147 (65.3%) had iron deficiency (Table 4).

Iron Deficiency and Iron-Deficiency Anemia

Iron deficiency was found in 156 (44.6%) participants (Table 3) while iron deficiency anemia (low MCV, low ferritin and low hemoglobin) was found in 138 (39.4%) of participants (Table 4). However, among 255 participants with anemia, 147 (65.3%) had iron deficiency. There was a significant positive correlation between hemoglobin and blood ferritin levels (Spearman's correlation coefficient = 0.6; $p < .01$ (Figure 1).

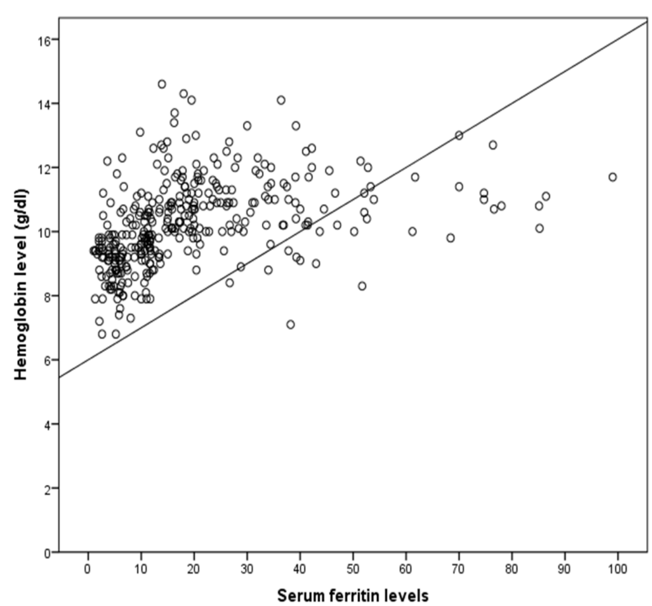
TABLE 2: Distribution of Anemia among Study Participants

Anemia status	Frequency	Percent
Normal (≥ 11gm/dl)	95	27.1
Mild anemia (10-10.9g/dl)	101	28.9
Moderate anemia (7-9.9)	152	43.4
Severe anemia (≤7g/dl)	2	0.6
Total	350	100.0

TABLE 1: Baseline Characteristics of Study Participants (N=350)

Variable	Number (n)	Percentage (%)
Sex		
Male	193	55.1
Female	157	44.9
Age group (months)		
<24 months	268	76.6
≥ 24 months	82	23.4
Gestation age at delivery period (weeks)		
<37 weeks	12	3.4
≥37 weeks	338	96.6
Nutritional status		
Normal	285	81.4
Mild malnutrition	55	18.7
Moderate malnutrition	10	8.9
Birth order of the child		
1st t child	168	48
2nd child	106	30.3
3rd child and above	76	21.7
Parental care		
Both parents	309	88.2
Single parent	41	11.8
Number of persons/households		
<6 people	320	91.4
6+people	30	8.6
Age when complementary feeding was initiated		
Still on exclusive breastfeeding	184	52.6
Less than 6 months	158	45.1
At 6 months or more	8	2.3

FIGURE 1: tionship Between Hemoglobin and Blood Ferritin Levels



Spearman's Correlation Coefficient=0.6, p<.01

TABLE 4: Morphological Classification of Anemia in Relation to Ferritin Levels

MCV status	Ferritin level status	Is the child anemic? (Hb<11g/dl)		Total
		Yes	No	
Low (<80fl)	Serum ferritin level status			
	Low	138	8	146
	Normal	101	63	164
	Total	239	71	310
Normal (≥80fl)	Serum ferritin level status			
	Low	9	1	10
	Normal	7	23	30
	Total	16	24	40
Total	Serum ferritin level status			
	Low	147	9	156
	Normal	108	86	194
	Total	255	95	350

TABLE 3: Factors Associated with Anemia Among Children Aged 3 to 59 months

Variable	Is the child anemic? (Hb<11g/dl) Yes n (%)	No n (%)	Total	Chi-Square test	P value
Age groups					
Less than 24 months	218 (81.6)	49 (18.4)	267 (100)	50	<.001
24 to 59 months	37 (44.6)	46 (55.4)	83 (100)		
Total	255 (72.9)	95 (27.1)	350 (100)		
Sex					
Female	109 (69.4)	48 (30.6)	157 (100)	1.69	.11
Male	146 (75.6)	47 (24.4)	193 (100)		
Total	255 (72.9)	95 (27.1)	350 (100)		
Birth weight					
Low birth weight (<2.5kg)	23 (74.2)	8 (25.8)	31 (100)	0.03	.86
Normal Birth weight (≥ 2.5kg)	232 (72.7)	87 (27.3)	319 (100)		
Total	255 (72.9)	95 (27.1)	350 (100)		
Gestation age at birth					
Preterm (<37 weeks)	9 (75)	3 (25)	12 (100)	0.29	.58
Term (≥37 weeks)	246 (72.8)	93 (27.2)	333 (100)		
Total	225 (79.2)	95 (27.1)	350 (100)		
Mother's age (years)					
≤ 20	24 (72.7)	9 (27.3)	33 (100)	0.47	.99
21-30	152 (73.1)	56 (26.9)	208 (100)		
31-40	72 (72.7)	27 (27.3)	88 (100)		
≥41	7 (70)	3 (30)	10 (100)		
Total	225 (79.2)	95 (27.1)	350 (100)		
Blood ferritin level					
Low (<12µg/L)	147 (94.2)	9 (5.8)	156 (100)	65	<.001
Normal (≥12µg/L)	108 (55.7)	86 (44.3)	194 (100)		
Total	255 (72.9)	95 (27.1)	350 (100)		
Age when complementary feeding started					
Exclusive breastfeeding	130 (70.7)	54 (29.3)	184 (100)	1.65	.44
Less than 6 months	120 (75.9)	38 (24.1)	158 (100)		
Six months or more	5 (62.5)	3 (37.5)	8 (100)		
Total	255 (72.9)	95 (27.1)	350 (100)		
Mother's level of education					
No formal education	12 (66.7)	6 (33.3)	18 (100)	3.8	.44
Primary education	7 (58.3)	5 (41.7)	12 (100)		
Secondary education	8 (72.7)	3 (27.3)	11 (100)		
Certificate to diploma	153 (76.2)	51 (23.8)	214 (100)		
Graduate/master/PHD	65 (68.4)	30 (31.6)	95 (100)		
Total	255 (72.9)	95 (27.1)	350 (100)		
Mother's source of income					
Employed in formal sector	17 (63)	10 (37)	27 (100)	2.7	.43
Housewife	137 (75.7)	44 (24.3)	181(100)		
Pet trader	100 (71.4)	40 (28.6)	140 (100)		
Others	1 (50)	1 (50)	2 (100)		
Total	255 (72.9)	95 (27.1)	355 (100)		

DISCUSSION

In this study, the prevalence of anemia was 72.9% which is relatively higher compared to the results from Tanzania Demographic Health Survey (TDHS) 2015-16, and a study by Kessy. J et al in Kilimanjaro, which showed an overall prevalence of 56% and 55.8%, respectively.[15,21,22] However, the findings in the Dar es Salaam cluster in TDHS, and another hospital-based study in Mwanza were similar to our findings. [22,23] Furthermore, the prevalence in this study was similar to other studies conducted in other Low and Middle-Income Countries (LMIC) which share similar socioeconomic characteristics.[4,25,26] However, the prevalence from our study is higher than the global estimates (39.7%).[27] This could be explained by previous studies findings which have implicated high prevalence of anemia in developing countries with poor dietary intake of iron containing foods such as green vegetables and meat; low socioeconomic status and infections such as malaria, recurrent diarrhea, and helminths infestations.[3,24,28]

We found that the magnitude of anemia and iron deficiency was relatively higher (81.6%) in the young group below 24 months compared to the older age group. This finding is similar to the findings from the TDHS 2015-16 which was estimated to be at 81%.[22] Also, other studies done in Zanzibar, Mwanza, and Kilimanjaro revealed the same trend.[21,24] Furthermore, most of the children who were anemic (94.2%) had iron deficiency anemia evidenced by microcytic hypochromic anemia with low serum ferritin levels. Further analysis showed that the hemoglobin levels were highly correlated with serum ferritin levels which suggests that most of anemia cases in children are contributed by iron deficiency.

These findings imply that there could be a lot of children under five who are anemic, and mostly likely as the result of nutritional deficiency of iron. This could be contributing to poor physical and cognitive development, with subsequent failure to attain their full potential. Vulnerability in the younger age group could be the result of rapid growth with subsequent high demand of daily intake of iron compounded by early weaning and inappropriate complementary feeding practices.[29,30] It is recommended that infants should be exclusively breastfed for 4- 6 months for optimal growth and prevention of micronutrients deficiency including iron.[31,32] However, in Tanzania, it is estimated that only 50-60% of infants are exclusively breastfed during their first 6months of age[29,33–35] ,which may be the significant contributor of the observed iron deficiency anemia in the younger age group in our study and other previous studies. Additionally, those living in urban area like in Dar es Salaam where our study was conducted are more likely not to breastfeed their children exclusively for the recommended period which may subject them to increased risk of iron deficiency anemia.[29,36]

The practice of mixed feeding before the recommended time such as use of cow's milk which is the most common substitute in low resources setting is associated with gut inflammation with subsequent malabsorption of nutrients including iron.[21,28] Furthermore, other mostly used complementary solid foods in children worldwide do not contain adequate iron to meet the physiological demand of rapidly growing infants.[37] WHO recommends that the composition of complementary foods should be similar to that of the breastmilk for optimal growth and development.[38] However, this may not be practical in developing countries with limited resources and research. Iron fortified foods and meat are the most recommended complementary source of iron.[37] However, these foods are expensive and not readily available in low resource setting.

This study had some limitations; most of the information was provided by parents, and some of the details could have been forgotten leading to recall bias. Moreover, previous studies have shown that recurrent infections in young children such as malaria, diarrhea and helminths infestations are associated with anemia and iron deficiency[4,24], however, we were limited in resources to screen for these illnesses. Furthermore, it is well known that low birth weight and prematurity delivery are associated with iron deficiency and anemia especially starting from six months of age, however, this was not evident in our study. This could have been resulted from not having enough participants who were born prematurely or with low birth weight, as we could not match participants by their birth weight. Nonetheless, we still believe that our findings show a big picture of the problem, which needs to be analyzed further and to provide appropriate solutions.

CONCLUSION

In conclusion, anemia is highly prevalent among children under five years of age in Kinondoni Municipal in Dar es salaam, and iron deficiency could be the main contributor. This could be an important bottleneck for them to survive and thrive. Henceforth, more implementation research should be conducted to evaluate effective preventive strategies such as promotion of exclusive breastfeeding for the first 4 to 6 months, continued breastfeeding up to at least 24 months, intensification of community education on appropriate complementary feeding practices, and ensured food security. Additionally, there is a need to conduct research on iron content in locally available foods and develop a local content specific dietary guideline for appropriate complimentary feeding.

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