

## RESEARCH ARTICLE

# Predictors of iron deficiency anaemia among children aged 6–59 months in Tanzania: Evidence from the 2015–16 TDHS-MIS cross-sectional household survey

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## Abstract

Iron deficiency anaemia remains a public health problem, particularly in children aged 6–59 months. This study assessed factors associated with iron deficiency anaemia among children aged 6–23 months, 24–59 months and 6–59 months in Tanzania. Data for this cross-sectional study were extracted from the 2015–16 Tanzania Demographic and Health Survey and Malaria Indicator Survey (2015–16 TDHS-MIS). The study covered 8014 children aged 6–59 months and their mothers. Iron deficiency anaemia was defined (haemoglobin < 11g/dL). Univariable and multivariable logistic regression analyses that adjust for clustering and sampling weights were conducted to describe the associations between anaemia and potential confounding variables. The prevalence of iron deficiency anaemia among children aged 6–23 months, 24–59 months and 6–59 months were 76%, 49% and 59%, respectively. Factors associated with increased odds of iron deficiency anaemia among children aged 6–23 months included a mother being employed, being a male child, child perceived to small size at birth by mothers, a mother being anaemic and children belonging to the poorest socio-economic quintile. In addition, being a mother with no schooling, children not being dewormed, a mother being anaemic, delivering a baby at home, child fever and stunting, were factors associated with increased odds of iron deficiency anaemia among children aged 24–59 months. Factors associated with increased odds of iron deficiency anaemia among children aged 6–59 months were: a mother being employed, being a mother with no schooling, being a male child, belonging to the 6–59 months age bracket, a mother having a BMI of between 19 and 25 kg/m<sup>2</sup>, a mother being anaemic, having a baby at home, children belonging to bigger households, child fever and stunting. Interventions to minimise the burden of iron deficiency anaemia in children should target employed and/or anaemic mothers, poor and rich households, as well as male children.

public repository. URL: [https://dhsprogram.com/data/dataset/Tanzania\\_Standard-DHS\\_2015.cfm?flag=0](https://dhsprogram.com/data/dataset/Tanzania_Standard-DHS_2015.cfm?flag=0).

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## Introduction

Anaemia, which is identified as a condition in which the blood haemoglobin concentration is lower than normal [1], and leads to poor cognitive and motor development in children and loss of work productivity in adulthood [2, 3], is a global health problem, particularly in developing countries [4, 5]. Iron deficiency anaemia has been found to be the major cause of anaemia, accounting for about 50% of all anaemia cases [3]. This proportion, however, may vary substantially across regions and countries [6]. In addition, anaemia could also be attributable to the effects of infectious diseases (particularly HIV, malaria, and helminth infections) [7] and genetic disorders of haemoglobin as well as other micronutrient deficiencies such as folic acid, vitamin A and vitamin B12 deficiencies [2].

As of 2015, it was estimated that 273 million (~ 42.6%) of under-5 children were anaemic, worldwide; whereas 60.2% of under-5 children in the African region were anaemic [8]. In Tanzania, anaemia among under-5 children remains high (58%) despite the efforts made by the government and other stakeholders in improving maternal, infant and young child health and nutrition services. Tanzanian children under 24 months of age are the most affected, with a peak prevalence of 81% among children aged 9–11 months [2, 9].

The situation of haemoglobinopathies causing hereditary haemolytic anaemia in Tanzania is very grim. A hospital-based, descriptive cross-sectional design was used to recruit newborns in 2009 and found that, out of 2,053 samples analysed, the prevalence of haemoglobinopathies was 18.2% (n = 374). The frequency of occurrence of abnormal haemoglobins was highest among participants whose parental origin was Coastal and Lake Zones [10]. Unfortunately, there is no much attempt at the national level to enlarge the epidemiological database and establishing specific programmes for screening populations at risk [11].

There has been a dearth of evidences on factors associated with Anaemia in children in Tanzania. For instance, Kejo and colleagues examined the prevalence of anaemia and its predictors among under-five children [12]. They used multivariable logistic regression to identify predictors of anaemia in children that include low birth weight, not consuming meat, not consuming vegetables, drinking milk and drinking. They concluded that low birth weight and dietary factors (i.e., low or non-consumption of iron-rich foods like meat, vegetables, and fruits) were predictors of anaemia among under-five children. However, the study by Kejo et al. [12] was limited in scope, as it covered only under-5 children in Arusha district. Another Tanzanian study by Simbauranga et al [13] sought to determine the prevalence and morphological types of anaemia and factors associated with severe anaemia in under-five children. In that study, factors related to child anaemia included unemployment of the parent, malaria parasitaemia and presence of sickle haemoglobin. However, this study was limited in scope too; as it covered only under-5 children admitted at Bugando Medical Centre in Mwanza district of Tanzania.

Due to the fact that anaemia is important in a national and global context; and given the limited studies on this burden in Tanzania [12–14], this current study utilized secondary data from the 2015–2016 Tanzania Demographic and Health Survey and Malaria Indicator Survey (TDHS-MIS) to assess the predictors of iron deficiency anaemia, the major cause of anaemia among children aged 6–23 months, 24–59 months and 6–59 months in Tanzania. The study results will support decision-makers, programme implementers, and academia at various planning, implementation, and training interventions focusing on prevention and control of nutrition anaemia.

## The theoretical framework of factors associated with iron deficiency anaemia in children

To analyse factors associated with iron deficiency anaemia in children in Tanzania, this current study adapted the Mosley and Chen conceptual framework to analyse child survival in

developing countries [15]. This framework, which was proposed in 1984 by Mosley and Chen, incorporated both social and biological factors associated with the survival of an infant. The adapted framework is presented in Fig 1.

## Methods

### Ethics statement

This study was based on an analysis of existing public domain survey datasets that are freely available online with all identifier information removed. The survey was approved by the Tanzania Ethics Committees i.e. the National Institute for Medical Research (NIMR) and, Zanzibar Medical Research and Ethics Committee (ZAMREC). Further, the survey was approved by Institutional Review Board of ICF International and the Centers for Disease Control and Prevention in Atlanta. Written consent was obtained from all respondents (parent/guardian) after being read a document emphasizing the voluntary nature of the survey and, all information was collected confidentially.

### Study design and study area

This was an analytical cross-sectional study conducted using nationally representative secondary data from the 2015–16 TDHS-MIS survey, which was conducted from August 2015 to March 2016 by the Tanzania National Bureau of Statistics (NBS) and the office of Chief Government Statistician (OCGS), Zanzibar, in collaboration with the Ministry of Health, Community Development, Gender, Elderly, and Children (MoHCDGEC) in Tanzania Mainland and the Ministry of Health, Zanzibar. The study included data both from urban and rural areas in the 30 regions of the United Republic of Tanzania, of which 25 regions were of Mainland Tanzania and 5 regions of Zanzibar [9]. The Tanzania DHS employs a multi-stage sampling procedure. The first stage involves a selection of a stratified sample from a list of enumeration areas (EAs) that have been obtained from the 2012 Population and Housing Census for United Republic of Tanzania conducted on the 26th August, 2012. These EAs are the clusters. This sample of EAs is selected with considerations to probability proportional to size (PPS) that takes into account the size of the enumeration area. At the second stage, after a complete list of households is available in each of the selected EAs, a fixed/variable number of households are selected by equal probability systematic sampling technique.

### Study population and sample size

The main objective of the 2015–16 TDHS-MIS survey was to provide up-to-date estimates of basic demographic and health indicators, including nutrition indicators for the prevalence of iron deficiency anaemia among children aged 6–59 months. The survey involved completed interviews with 13,266 ever-married women aged 15–49 years (response rate 97%) from sampled households. The survey utilized four questionnaires: a household, women's, men's and biomarker questionnaire. A household questionnaire was used to collect socio-demographic data for all household members, while the women questionnaire was used to gather information about maternal and child health. The Biomarker questionnaire was used to document anthropometric measurements (height and weight) and the iron deficiency anaemia test results for the children aged 6–59 months and the women of reproductive age 15–49 yrs. The present analysis was restricted to children aged 6–59 months and lived with the respondent (women aged 15–49 years). This yielded a weighted total of 8014 children aged 6–59 months.

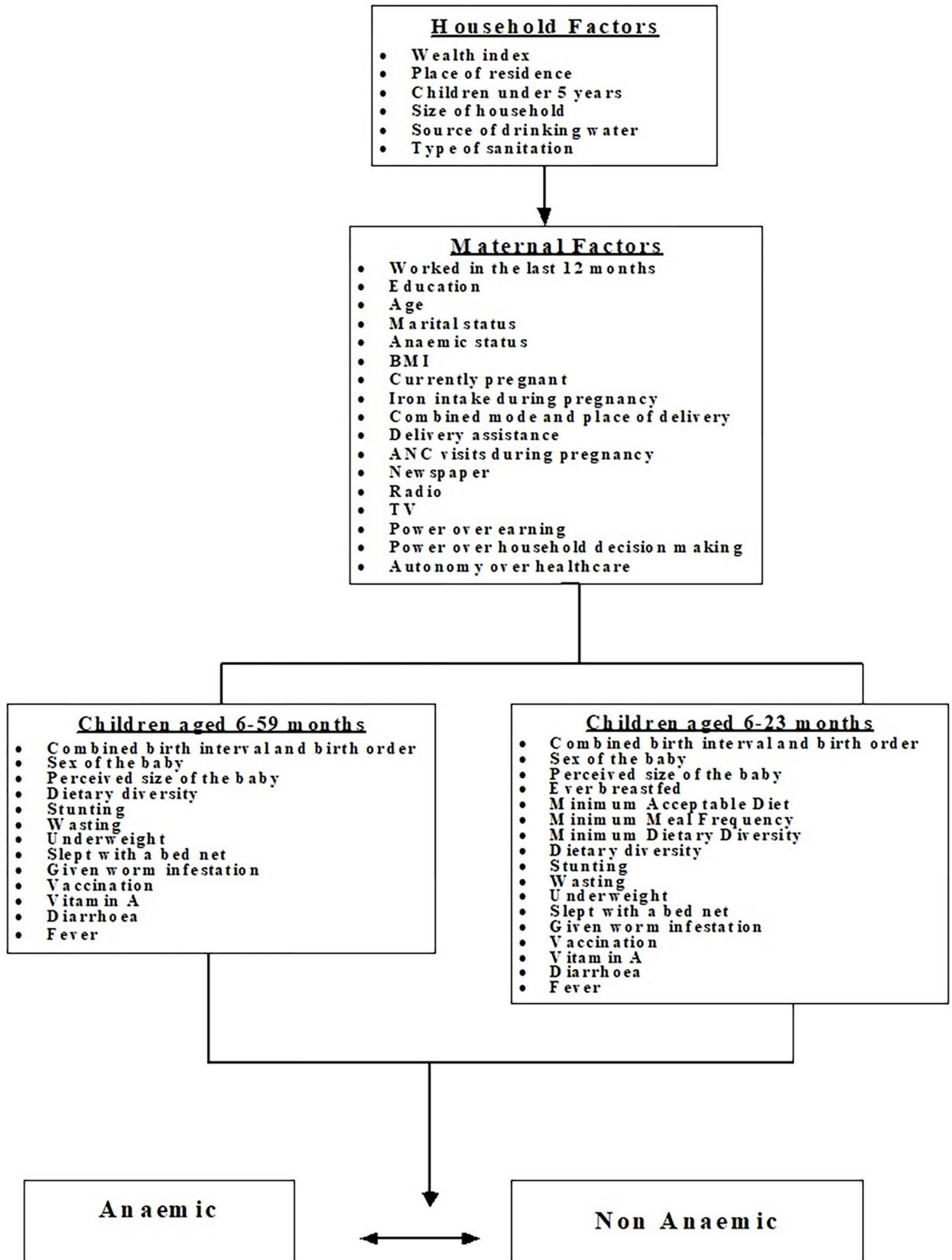


Fig 1. Flow chart for factors associated with anaemia among children 6–59 months.

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## Study outcomes

The outcome variable for this analysis is iron deficiency anaemia among children aged 6–59 months. Iron deficiency anaemia defined as a condition with a haemoglobin level below 11.0 g/dl as defined by the WHO [1].

## Predictor variables

The choice of independent variables for this study was informed by previous literature [16–19] and their availability in the 2015–16 TDHS dataset. These variables were categorised into maternal factors, child factors and household factors.

Participant's work status, level of education, age, marital status, anaemia status, body mass index (BMI), pregnancy status, uptake of iron during pregnancy, place of delivery, mode of delivery, type of delivery assistance, number of antenatal (ANC) clinic visits, access to newspaper/magazine, the radio and television, power over earnings, household decision making and autonomy over health care constituted the maternal factors. Child factors included: combined birth interval and birth order, sex, size at birth, age, breastfeeding status, meetings requirements for minimum acceptable diet (MAD), minimum meal frequency (MMF), minimum dietary diversity (MDD), MDD status, anthropometric status (stunting, wasting and underweight), use of bed net, uptake of a drug to prevent worm infestation, vaccination status and illness (diarrhoea and fever). The household factors were household wealth index, type of residence, number of under-5 children, household size, quality of the source of drinking water, and quality of toilet facility. The household wealth index was represented as a score of household assets through the principal components analysis method (PCA) [20]. Scores were assigned to each de jure household member after the index was computed, ranking each member of the sample by their score. In this study, the wealth index was categorized into five quintiles, namely, poorest, poorer, middle, rich and richest. The bottom 20% of the households were referred to as the poorest; the next bottom 20% was referred to as the poorer, the next bottom 20% was referred to as the middle-class, the next 20% was referred to as the richer, and the top 20% was referred to as the richest. Full details of the definition of the categorisation of all potential predictor variables used in the study are presented in Table 1.

## Anthropometric measurements

**Anthropometry.** Height and weight measurements were taken for all sampled children and women aged 15–49 years in Tanzania; including those not biological offspring of the women interviewed in the survey. Each trained interviewer carried a scale and measuring board. The scales were lightweight, bathroom-type with a digital screen. Recumbent heights were measured for children aged less than 24 months, whilst the standing heights of older children were measured [9].

**Testing for iron deficiency anaemia.** All the children aged 6–59 months in all selected households were tested for anaemia after receiving consent from their parents or guardians. Blood specimens were collected from all children aged 6–59 months and women of reproductive age 15–49 years for haemoglobin measurements. Blood samples were drawn from a drop of blood taken from a finger prick (or heel prick in children aged 6–11 months) and collected in the micro cuvette. Haemoglobin analysis was carried out on-site, using a battery-operated portable HemoCue analyser. Results for the anaemia test were given instantly to all the respondents. Parents/guardians of the children who had haemoglobin level less than 7 g/dl were advised to take the child to a health facility for treatment. The same advice was given to all women found to be anaemia, i.e. having a haemoglobin level (hb) of less than 7g/dl [1].

**Table 1. Definition and categorisation of variables used in the study.**

Independent variables	Categorisation
<b>Household factors</b>	
Household wealth Index	hv217 (the household wealth index factor score) constructed by DHS based on a selected set of household assets. In quintiles, 1 = richest; 2 = richer; 3 = middle; 4 = poorer; 5 = poorest)
Residence	In the 2 following categories: (1 = urban; 2 = rural)
Number of children under 5 years	In the 3 following categories: (1 = None; 2 = 1 to 2; 3 = $\geq 3$ )
Household size	In the 2 following categories: (1 = 2–5; 2 = $>6$ )
Source of drinking water	In the 2 following categories: (1 = improved; 2 = Unimproved) piped into dwelling, piped to yard or plot, piped to neighbour, public tap or standpipe, tube well or borehole, protected well, protected spring, tanker truck and bottled water. Unimproved otherwise
Type of toilet facility	In the 2 following categories: (1 = improved; 2 = Unimproved) Improved was flush to piped sewer system, flush to septic tank, flush to pit latrine, ventilated improved pit latrine, pit latrine with slab, and composting toilet. Unimproved otherwise.
<b>Maternal factors</b>	
Maternal working status	In the 2 following categories: (1 = not working; 2 = working (for the past 12 months))
Maternal education	In the 3 following categories: (1 = Secondary or higher; 2 = Primary; 3 = No education)
Maternal age	In the 3 following categories: (1 = 15–19 years; 2 = 20–34 years; 3 = 35–49 years)
Marital status	In the 2 following categories: (1 = Currently married; 2 = divorced/separated/widow)
Maternal anaemia	In the 2 following categories: (1 = Non anaemic; 2 = anaemic) haemoglobin (Hb) $< 110\text{g/dl}$ for pregnancy women
Maternal BMI	In the 3 following categories: (1 = $25+ \text{kg/m}^2$ ; 2 = $19\text{--}25 \text{kg/m}^2$ ; 3 = $\leq 18.5\text{kg/m}^2$ )
Mothers currently pregnant	In the 2 following categories: (1 = Not at all; 2 = Yes)
Mothers taking iron during pregnancy	In the 2 following categories: (1 = Not at all; 2 = Yes)
Combined mode and place of delivery	In the 3 following categories: (1 = Vaginal; 2 = Caesarean; 3 = Home)
Type of delivery assistance	In the 2 following categories: (1 = Health professional <sup>§</sup> ; 2 = non-Health professional)
Antenatal Clinic visits	In the 4 following categories: (1) 8+ antenatal care visits, (2) 4–7 antenatal care visits, and (3) 1–3 antenatal care visits (4) no antenatal care visits from a skilled provider for the most recent birth
mothers reading newspapers	In the 2 following categories: (1 = At least once a week; 2 = Less than once a week and 3 = Never)
mothers listening to radio	In the 2 following categories: (1 = At least once a week; 2 = Less than once a week and 3 = Never)
mothers watching television	In the 2 following categories: (1 = At least once a week; 2 = Less than once a week and 3 = Never)
Power over earning	In the 2 following categories: (1 = Yes; 2 = No) Yes- respondent alone, respondent and husband/partner. No- otherwise
Power over household decision making	In the 2 following categories: (1 = Yes; 2 = No) Yes- respondent alone, respondent and husband/partner. No- otherwise
Autonomy over health care	In the 2 following categories: (1 = Yes; 2 = No) Yes- respondent alone, respondent and husband/partner. No- otherwise
<b>Child Factors</b>	

(Continued)

**Table 1.** (Continued)

Independent variables	Categorisation
Combined birth interval and birth order	(1 = 1st birth rank; 2 = 2nd/3rd birth rank, more than 2 years interval; 3 = 2nd/3rd birth rank, less than or equal to 2 years; 4 = 4th birth rank, more than 2 years interval; 5 = 4th birth rank, less than or equal to 2 years)
Sex of baby	In the 2 following categories: (1 = Male; 2 = Female)
Size of baby	In the 3 following categories: (1 = Large; 2 = Average; 3 = Small)
Age of child (months)	In the 2 following categories: (1 = 6–23 months; 2 = 24–59 months.)
Child ever breastfed	In the 2 following categories: (1 = Never Breastfed; 2 = Ever Breastfed)
Minimum Acceptable Diet	In the 2 following categories: (1 = No; 2 = Yes/some)
Minimum Meal Frequency	In the 2 following categories: (1 = No; 2 = Yes/some)
Minimum Dietary Diversity	In the 2 following categories: (Yes; 1 = ( $\geq$ 4 of 7 food groups) = No; 2 = ( $<$ 4 of 7 food groups).
Dietary Diversity	In the 3 following categories: (1 = High Diversity; 2 = Moderate Diversity; 3 = Low Diversity) High diversity (5–7 food groups); moderate diversity (3–4 food groups) & low diversity (0–2 food groups)
Stunting	In the 2 following categories: (1 = Not stunted; 2 = stunted (height-for-age z-score $<$ -2 SD)
Wasting	In the 2 following categories: (1 = Not wasted; 2 = wasted (weight-for-height z-score $<$ -2 SD)
Underweight	In the 2 following categories: (1 = Not underweight; 2 = underweight (weight-for-age z-score $<$ -2 SD)
Children under 5 years who slept with bed net	In the 2 following categories: (1 = No; 2 = Yes)
Children given drugs for preventing worm infestation	In the 2 following categories: (1 = No; 2 = Yes)
Children fully vaccinated	In the 2 following categories: (1 = None; 2 = full)
Vitamin A	In the 2 following categories: (1 = No; 2 = Yes)
Had diarrhoea recently	In the 2 following categories: (1 = No; 2 = Yes)
Had fever in last 2 weeks	In the 2 following categories: (1 = No; 2 = Yes)

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## Statistical analysis

All analyses were conducted using Stata version 14.0 (Stata Corp, College Station, Texas, USA) to determine factors associated with iron deficiency anaemia among children aged 6–23 months, 24–59 months and 6–59 months in Tanzania, the dependent variable was expressed as a dichotomous one; that is, category 0 (not anaemic (hb  $>$  11g/dl) and category 1 (anaemic (hb  $<$  11g/dl). Preliminary analyses involved the frequency distribution of all potential predictor variables used in this study. An estimation of the prevalence and corresponding confidence intervals of iron deficiency anaemia among children aged 6–23 months, 24–59 months and 6–59 months then followed. We then performed univariate binary logistic regression analysis that adjusts for clustering and sampling weights to examine the association between anaemic children aged 6–23 months and overall anaemia among children aged 6–59 months and multi-variable survey logistic regression analyses that adjust for clustering and sampling weights to examine the factors associated with anaemia after controlling for confounding variables (Household-, maternal- and child-level factors).

A manual process elimination method was used in the multivariable analysis models to identify factors that were significantly associated with the study outcome, using a 5% significance level. In order to avoid or minimise any statistical errors in our analysis, we repeated the manual elimination process by using a different approach. This involved three steps: (1) only potential risk factors with P-value  $<$  0.20 were entered in the backward elimination process,

(2) the backward elimination was tested by including all variables (all potential risk factors); and, (3) Any collinearity was tested and reported in the final model. The odds ratios with 95% confidence intervals (CIs) were calculated in order to assess the adjusted risk of independent variables; and those with  $P < 0.05$  were retained in the final model.

## Results

### Characteristics of the sample

Of the 8014 mothers (of children aged 6–59 months) considered in this study, 73.1% were unemployed (Table 2). Approximately one out of every five mothers (21.1%) had no schooling, and the majority of the mothers were aged 20–34 years (68.8%) and never been married (87.4%). Less than half of the mothers (48.3%) were anaemic, and only about a quarter of them (25.1%) had a BMI of above 25 kg/m<sup>2</sup>. Only 10.4% of the mothers were pregnant, and out of these, the majority (80.3%) took iron during their pregnancy. The majority of the mothers (62.5%) delivered their babies at a health facility, and approximately nine out of ten of them (94.2%) were delivered through a non-caesarean section. More than 60% of the mothers were delivered with the help of health professionals, and more than one-third of them (34.1%) did not attend any ANC clinics. The proportion of mothers who had no access to newspapers/magazines, the radio and television was 63.8%, 25.4% and 57.7%, respectively. The proportion of mothers alone having power over earnings and household decision making as well as autonomy over health care was 46.7%, 66.8% and 58.7%, respectively. For children aged 6–59 months, close to a quarter (24.5%) of them were firstborn. The proportion of males, small size and children aged 24–59 months was 50.6%, 10.2% and 64.1%, respectively. The proportion of children aged 6–23 months who were ever breastfed and met the requirements for MAD, MMF and MDD, and being exposed to low dietary diversity was 97.9%, 6.8%, 33.8%, and 22.9%, respectively. A large majority (85.6%) of children aged 6–59 months were exposed to low dietary diversity. The proportion of children aged 6–59 months who were stunted, wasted and underweight was 36.6%, 4.3% and 14.4%, respectively. The proportion of children aged less than 5 years who did not sleep under bed net, children aged 6–59 months who were not given any drugs to prevent worm infestation, were not fully vaccinated, did not take vitamin A, had no diarrhoea and had no fever was 33.6%, 62.6%, 99%, 58.5%, 87.1% and 80.7% respectively.

Close to a quarter (24%) of children aged 6–59 months lived in the poorest households and approximately 73% of them lived in rural areas. More than half the children aged 6–59 months lived in households with more than six people (59.7%), improved source of drinking water (54.4%) and unimproved toilet facility (55.9%).

As shown in Fig 2, the prevalence of iron deficiency anaemia among children aged 6–23 months and 24–59 months were 75.8% and 48.6%, respectively. However, the figure showed that about two-thirds of the children aged 6–59 months (58.8%) are anaemic.

### Factors associated with iron deficiency anaemia in children aged 6–23 months

Factors significantly associated with increased odds of anaemia among children aged 6–23 months included: being a working mother [Adjusted odds ratio (OR): 1.43; 95% confidence interval (CI): (1.13, 1.82)], being a male child [OR: 1.46; 95% CI: (1.17, 1.82)], child being considered small at birth [OR: 1.77; 95% CI: (1.22, 2.56)], being an anaemic mother [OR: 2.28; 95% CI: (1.87, 2.79)] and a child belonging to the poorest socioeconomic quintile [OR: 2.28; 95% CI: (1.87, 2.79)] (Table 3).

Table 2. Household, maternal, and child-level characteristics of children aged 6–23 months, 24–59 months and 6–59 months, Tanzania, 2015–16 (n = 8014).

Characteristics	6–23 months		24–59 months		6–59 months	
	n (weighted)	Percentage (%)	n (weighted)	Percentage (%)	n (weighted)	Percentage (%)
<b>Household characteristics</b>						
<b>Household Wealth Index</b>						
Richest	562	17.4	961	16.7	1524	17.0
Richer	614	19.0	1055	18.3	1669	18.6
Middle	605	18.8	1119	19.4	1725	19.2
Poorer	682	21.1	1229	21.3	1911	21.3
Poorest	762	23.6	1394	24.2	2156	24.0
<b>Place of residence</b>						
Urban	910	28.2	1534	26.6	2444	27.2
Rural	2315	71.8	4225	73.4	6540	72.8
<b>Number of children under 5 years</b>						
None	144	5.3	319	6.5	463	6.1
1 to 2	2301	84.4	4109	84.0	6409	84.2
≥3	280	10.3	464	9.5	744	9.8
<b>Household Size (grouped)</b>						
1 to 5	1311	40.6	2351	40.8	3662	40.8
>6	1915	59.4	3407	59.2	5322	59.2
<b>Source of drinking water</b>						
Not improved	1441	44.7	2652	46.1	4093	45.6
Improved	1785	55.3	3106	53.9	4891	54.4
<b>Type of toilet facility</b>						
Improved	862	44.6	1512	43.8	2374	44.1
Unimproved	1072	55.4	1942	56.2	3014	55.9
<b>Maternal characteristics</b>						
<b>Respondent worked in the last 12 months</b>						
Non-working	2257	70.0	4311	74.9	6568	73.1
Working	968	30.0	1448	25.1	2416	26.9
<b>Mother's Education</b>						
Secondary	561	17.4	713	12.4	1274	14.2
Primary	2044	63.4	3771	65.5	5815	64.7
No education	621	19.3	1274	22.1	1895	21.1
<b>Mother's age (years)</b>						
15–19	358	11.1	149	2.6	507	5.6
20–34	2247	69.7	3930	68.3	6177	68.8
35–49	621	19.3	1679	29.2	2300	25.6
<b>Mother's marital status</b>						
Never in marriage	2618	88.6	4820	86.7	7438	87.4
Currently married	335	11.3	741	13.3	1077	12.6
<b>Maternal anaemia</b>						
Non-anaemic	1684	54.0	2803	50.5	4487	51.7
Anaemic	1437	46.0	2751	49.5	4188	48.3
<b>Maternal BMI (Kg/m<sup>2</sup>)</b>						
25+	695	21.8	1559	27.2	2254	25.3
18.5–24.9	2336	73.1	3922	68.5	6258	70.2
<18.5	163	5.1	243	4.2	406	4.5
<b>Currently Pregnant</b>						

(Continued)

Table 2. (Continued)

Characteristics	6–23 months		24–59 months		6–59 months	
	n (weighted)	Percentage (%)	n (weighted)	Percentage (%)	n (weighted)	Percentage (%)
No	3013	93.4	5038	87.5	8051	89.6
Yes	213	6.6	720	12.5	933	10.4
<b>Taking iron during pregnancy</b>						
No	567	18.3	628	21.1	1195	19.7
Yes	2528	81.7	2350	78.9	4878	80.3
<b>Combined mode and place of delivery</b>						
Vaginal	1887	58.4	3203	55.6	5665	56.7
Caesarean section	216	6.7	306	5.3	5809	5.8
Home	1123	34.8	2250	39.1	3754	37.5
<b>Delivery assistance</b>						
Health professional	2083	64.5	3533	61.4	5616	62.5
Non-health professional	1143	35.4	2226	38.7	3368	37.5
<b>Antenatal Clinical visits</b>						
8+	29	0.9	74	1.3	103	1.2
4 to 7	1527	47.2	1576	27.3	3103	34.5
1 to 3	1465	45.4	1282	22.3	2747	30.6
None	208	6.5	2855	49.1	3063	33.7
<b>Mother read magazine or newspaper</b>						
At least	320	9.9	506	8.8	826	9.2
Less than	874	27.1	1556	27.0	2430	27.1
Never	2031	63.0	3695	64.2	5726	63.8
<b>Mother listened to radio</b>						
At least	1335	41.4	2272	39.5	3607	40.2
Less than	1092	33.9	2000	34.7	3092	34.4
Never	799	24.8	1486	25.8	2285	25.4
<b>Mother watched television</b>						
At least	630	19.5	1018	17.7	1648	18.3
Less than	764	23.7	1390	24.1	2154	24.0
Never	1831	56.8	3351	58.2	5182	57.7
<b>Mother Power over earnings</b>						
No	1766	54.8	3027	52.6	4793	53.4
Yes	1459	45.2	2731	47.4	4191	46.7
<b>Mother Power over household decision making</b>						
No	1096	34.0	1891	32.8	2987	33.3
Yes	2129	66.0	3868	67.2	5997	66.8
<b>Mother autonomy over health care</b>						
No	1345	41.7	2362	41.0	3707	41.3
Yes	1880	58.3	3396	59.0	5277	58.7
<b>Child characteristics</b>						
<b>Combined birth interval and birth order</b>						
1st birth rank	875	27.1	1323	23.0	2,198	24.5
2nd/3rd birth rank, more than 2 years interval	1140	35.4	2090	36.3	3230	36.0
2nd/3rd birth rank, less than or equal to 2	308	9.5	594	10.3	902	10.0
4th birth rank, more than 2 years interval	704	21.8	1336	23.2	2040	22.7
4th birth rank, less than or equal to 2	198	6.1	416	7.2	614	6.8
<b>Sex of child</b>						

(Continued)

Table 2. (Continued)

Characteristics	6–23 months		24–59 months		6–59 months	
	n (weighted)	Percentage (%)	n (weighted)	Percentage (%)	n (weighted)	Percentage (%)
Female	1588	49.2	2849	49.5	4437	49.4
Male	1637	50.8	2909	50.5	4547	50.6
<b>Perceived size of baby</b>						
Large	619	19.4	1101	19.3	1720	19.3
Average	2224	69.7	4060	71.0	6284	70.5
Small	350	11.0	554	9.7	904	10.2
<b>Child's age (months)</b>						
6 to 23					3225	35.9
24 to 59					5758	64.1
<b>Ever Breastfed</b>						
No	53	2.1				
Yes	2444	97.9				
<b>Minimum Acceptable Diet</b>						
No	3005	93.2				
Yes	220	6.8				
<b>Minimum meal frequency</b>						
No	2134	66.2				
Yes	1091	33.8				
<b>Minimum Dietary Diversity</b>						
No	2488	77.1				
yes	738	22.9				
<b>Dietary Diversity</b>						
High	236	10.1	105	2.0	340	4.5
Moderate	502	21.5	251	4.8	753	9.9
Low	1602	68.5	4917	93.3	6519	85.6
<b>Stunted</b>						
No	2047	68.5	2912	60.3	4959	63.4
Yes	940	31.5	1919	39.7	2859	36.6
<b>Wasted</b>						
No	2809	94.0	4661	96.8	7470	95.7
Yes	179	6.0	153	3.2	332	4.3
<b>Underweight</b>						
No	2593	86.4	4125	85.2	6718	85.6
Yes	410	13.7	718	14.8	1128	14.4
<b>Children &lt;5 slept with bed net</b>						
Yes	2150	68.8	3563	65.0	5713	66.4
No	975	31.2	1918	35.0	2893	33.6
<b>Given drugs for preventing worm infestation</b>						
No	2190	71.1	3124	57.8	5314	62.6
Yes	891	28.9	2278	42.2	3170	37.4
<b>Fully Vaccinated</b>						
No	3208	99.5	5690	98.8	8897	99.0
Yes	18	0.6	69	1.2	87	1.0
<b>Vitamin A</b>						
No	1739	56.9	3114	59.4	4853	58.5
Yes	1320	43.2	2126	40.6	3446	41.5

(Continued)

Table 2. (Continued)

Characteristics	6–23 months		24–59 months		6–59 months	
	n (weighted)	Percentage (%)	n (weighted)	Percentage (%)	n (weighted)	Percentage (%)
<i>Had diarrhoea in the last two weeks</i>						
No	2402	78.6	4780	92.2	7182	87.1
Yes	654	21.4	406	7.8	1061	12.9
<i>Had fever in the last two weeks</i>						
No	2376	77.7	4316	82.5	6692	80.7
yes	682	22.3	914	17.5	1596	19.3

<https://doi.org/10.1371/journal.pgph.0001258.t002>

### Factors associated with iron deficiency anaemia in children aged 24–59 months

Being a mother with no schooling [OR: 1.54; 95% CI: (1.18, 2.00)], being an anaemic mother [OR: 1.77; 95% CI: (1.54, 2.04)], having a baby delivered at home [OR: 1.27; 95% CI: (1.09, 1.48)], a child having fever [OR: 1.61; 95% CI: (1.32, 1.95)] and a child being stunted [OR: 1.46; 95% CI: (1.25, 1.71)] were the factors associated with increased odds of anaemia among

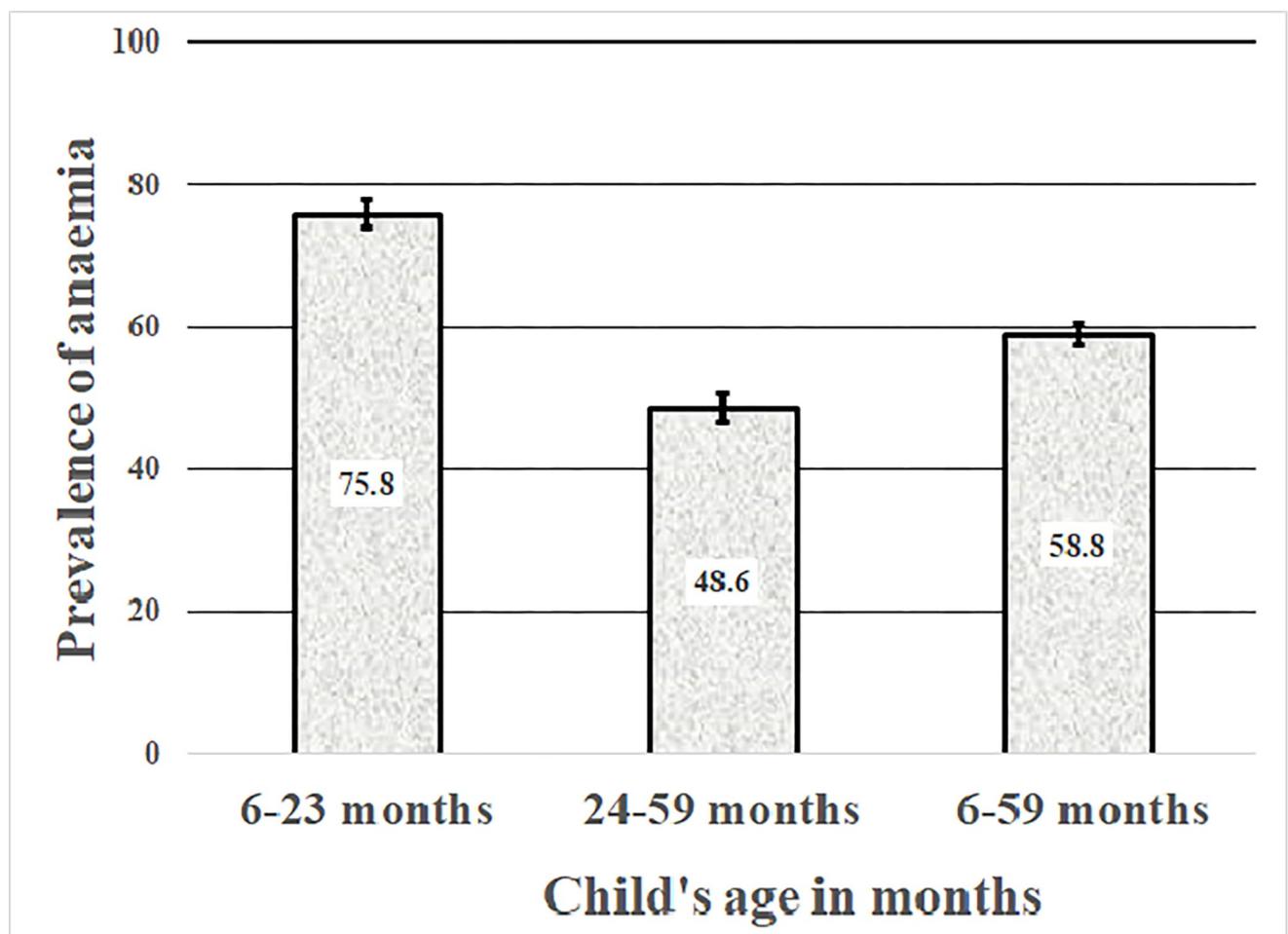


Fig 2. Prevalence and 95% confidence intervals of anaemia among children aged 6–23 months, 24–59 months and 6–59 months.

<https://doi.org/10.1371/journal.pgph.0001258.g002>

Table 3. Univariate and multivariate analyses of the odds of a child aged 6–23 months being anaemic—Tanzania 2015–16.

Characteristics	Unadjusted	P-Value	Adjusted	P-Value
	OR (95% CI)		OR (95% CI)	
<b>Household Factors</b>				
<b>Household Wealth Index</b>				
Richest	1.00		1.00	
Richer	1.13 (0.83,1.53)	0.445	1.04 (0.75, 1.45)	0.791
Middle	1.24 (0.91,1.71)	0.172	1.29 (0.91, 1.82)	0.142
Poorer	1.18 (0.86,1.61)	0.303	1.20 (0.85, 1.69)	0.279
Poorest	1.44 (1.08,1.94)	0.014	1.50 (1.10, 2.05)	0.010
<b>Type of residence</b>				
Urban	1.00			
Rural	1.12 (0.91,1.39)	0.281		
<b>Number of children under 5 years</b>				
None	1.00			
1 to 2	0.86 (0.36,2.09)	0.744		
≥3	1.43 (0.53,3.84)	0.476		
<b>Household Size (grouped)</b>				
1 to 5	1.00			
>6	1.23 (1.01,1.51)	0.043		
<b>Source of drinking water</b>				
Not improved	1.00			
Improved	0.78 (0.63,0.98)	0.033		
<b>Type of toilet facility</b>				
Improved	1.00			
Unimproved	1.32 (1.02,1.72)	0.036		
<b>Maternal Factors</b>				
<b>Respondent worked in the last 12 months</b>				
Non-working	1.00		1.00	
Working	1.47 (1.17,1.84)	0.001	1.43 (1.13, 1.82)	0.003
<b>Mother's Education</b>				
Secondary	1.00			
Primary	1.08 (0.85,1.39)	0.523		
No education	1.43 (1.01,2.02)	0.044		
<b>Mother's age (years)</b>				
15–19	1.00			
20–34	0.73 (0.51,1.03)	0.075		
35–49	0.64 (0.42,0.98)	0.038		
<b>Mother's marital status</b>				
Never in marriage	1.00			
Currently married	0.99 (0.70,1.42)	0.973		
<b>Maternal anaemia</b>				
Non-anaemic	1.00		1.00	
Anaemic	1.44 (1.08,1.94)	<0.001	2.28 (1.87, 2.79)	<0.001
<b>Maternal BMI (Kg/m<sup>2</sup>)</b>				
25+	1.00			
18.5–24.9	1.34 (1.05,1.70)	0.019		
<18.5	1.61 (1.01,2.56)	0.045		
<b>Currently Pregnant</b>				

(Continued)

Table 3. (Continued)

Characteristics	Unadjusted	P-Value	Adjusted	P-Value
	OR (95% CI)		OR (95% CI)	
No	1.00			
Yes	1.54 (0.97,2.44)	0.065		
<b>Taking iron during pregnancy</b>				
No	1.00			
Yes	1.04 (0.80,1.37)	0.754		
<b>Combined mode and place of delivery</b>				
Vaginal	1.00			
Caesarean section	0.68 (0.46,1.01)	0.055		
Home	1.05 (0.84,1.32)	0.661		
<b>Delivery assistance</b>				
Health professional	1.00			
Non-health professional	1.01 (0.80,1.26)	0.953		
<b>Antenatal Clinical visits</b>				
8+	1.00			
4 to 7	1.11 (0.34,3.51)	0.861		
1 to 3	1.21 (0.38,3.83)	0.740		
None	1.82 (0.53,6.39)	0.345		
<b>Mother read magazine or newspaper</b>				
At least	1.00			
Less than	1.10 (0.77,1.57)	0.612		
Never	1.11 (0.79,1.55)	0.554		
<b>Mother listened to radio</b>				
At least	1.00			
Less than	1.05 (0.85,1.31)	0.650		
Never	1.23 (0.95,1.58)	0.113		
<b>Mother watched television</b>				
At least	1.00			
Less than	1.43 (1.06,1.94)	0.020		
Never	1.16 (0.91,1.47)	0.239		
<b>Mother power over earnings</b>				
No	1.00			
Yes	0.90 (0.74,1.10)	0.292		
<b>Mother power over household decision making</b>				
No	1.00			
Yes	0.82 (0.66,1.03)	0.082		
<b>Mother autonomy over health care</b>				
No	1.00			
Yes	0.81 (0.66,0.99)	0.038		
<b>Child Factors</b>				
<b>Combined birth interval and birth order</b>				
1st birth rank	1.00		1.00	
2nd/3rd birth rank, more than 2 years interval	0.80 (0.61,1.05)	0.103	0.79 (0.60,1.04)	0.103
2nd/3rd birth rank, less than or equal to 2	0.87 (0.61,1.25)	0.458	0.87 (0.61,1.24)	0.458
4th birth rank, more than 2 years interval	0.91 (0.68,1.23)	0.546	0.91 (0.67,1.22)	0.546
4th birth rank, less than or equal to 2	0.74 (0.48,1.14)	0.171	0.73 (0.47,1.14)	0.171
<b>Sex of child</b>				

(Continued)

Table 3. (Continued)

Characteristics	Unadjusted	P-Value	Adjusted	P-Value
	OR (95% CI)		OR (95% CI)	
Female	1.00		1.00	
Male	1.35 (1.10,1.67)	0.004	1.46 (1.17, 1.82)	0.001
<b>Size of baby</b>				
Large	1.00		1.00	
Average	1.36 (1.07,1.72)	0.012	1.35 (1.06, 1.73)	0.015
Small	1.79 (1.27,2.51)	0.001	1.77 (1.22, 2.56)	0.002
<b>Ever Breastfed</b>				
No	1.00			
Yes	1.08 (0.25,4.66)	0.917		
<b>Minimum Acceptable Diet</b>				
No	1.00			
Yes	0.93 (0.66,1.31)	0.683		
<b>Minimum meal frequency</b>				
No	1.00			
Yes	1.16 (0.95,1.42)	0.126		
<b>Minimum Dietary Diversity</b>				
No	1.00			
Yes	0.81 (0.64,1.02)	0.083		
<b>Dietary Diversity</b>				
High	1.00			
Moderate	1.27 (0.82, 1.97)	0.290		
Low	1.47 (0.99, 2.14)	0.051		
<b>Stunted</b>				
No	1.00			
Yes	1.06 (0.87,1.30)	0.511		
<b>Wasted</b>				
No	1.00			
Yes	1.66 (1.01,2.70)	0.042		
<b>Underweight</b>				
No	1.00			
Yes	1.32 (0.98,1.77)	0.060		
<b>Children &lt;5 slept with bed net</b>				
Yes	1.00			
No	1.04 (0.84,1.28)	0.714		
<b>Given drugs for preventing worm infestation</b>				
No	1.00			
Yes	0.86 (0.69,1.05)	0.157		
<b>Fully Vaccinated</b>				
No	1.00			
Yes	0.56 (0.14,2.28)	0.426		
<b>Vitamin A</b>				
No	1.00			
Yes	0.79 (0.64,0.98)	0.036		
<b>Had diarrhoea in the last two weeks</b>				
No	1.00			
Yes	1.20 (0.94,1.52)	0.133		

(Continued)

Table 3. (Continued)

Characteristics	Unadjusted	P-Value	Adjusted	P-Value
	OR (95% CI)		OR (95% CI)	
<b>Had fever in the last two weeks</b>				
No	1.00			
Yes	1.21 (0.94,1.55)	0.128		

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children aged 24–59 months. The odds of being anaemic was significantly lower among children aged 24–59 months who were dewormed compared with those who were not [(OR: 0.84; 95% CI: 0.72, 0.98)] (Table 4).

### Factors associated with iron deficiency anaemia in children aged 6–59 months

Factors significantly associated with increased odds of anaemia among children aged 6–59 months were: being a working mother [OR: 1.2; 95% CI: (1.03, 1.38)], being a mother with no schooling [OR: 1.46; 95% CI: (1.17, 1.84)], being a male child [OR: 1.14; 95% CI: (1.02, 1.27)], being a child within the 6–59 months age bracket [OR: 3.66; 95% CI: 3.27, 4.1)], being a mother with BMI between 19 and 25 kg/m<sup>2</sup> [OR: 1.25; 95% CI: 1.08, 1.45)], being an anaemic mother [OR: 1.86; 95% CI: 1.65, 2.09)], having a baby at a non-institutional facility [OR: 1.15; 95% CI: (1.01, 1.32)], belonging to richer households [OR: 1.15; 95% CI: 1.02, 1.3)], a child having fever [OR: 1.44; 95% CI: 1.23, 1.68)], a child being stunted [OR: 1.31; 95% CI: 1.14, 1.5)], shown in Table 5.

### Discussion

This current study examined the prevalence and significant factors associated with iron deficiency anaemia among children aged 6 to 59 months in Tanzania. Our study revealed that the prevalence of iron deficiency anaemia was 75.8% and 48.6% for children aged 6–23 months and 24–59 months, respectively. Furthermore, 58.8% of children aged 6–59 months were found to be anaemic. Predictors of iron deficiency anaemia among children aged 6–23 months included: maternal work and anaemia status, sex and size and household wealth index of the child. Factors associated with iron deficiency anaemia among children aged 24–59 months included: maternal anaemia status, place of delivery of baby, illness and anthropometry. For children aged 6–59 months, factors associated with iron deficiency anaemia included: maternal work status, level of education, BMI, anaemia status, place of delivery, sex of child, size of household, illness and child anthropometry. The high prevalence of iron deficiency anaemia among children in the lowest age bracket (6–23 months) is higher than the average African prevalence of this condition of 60.2% [8]. The high prevalence of iron deficiency anaemia among children in the 6–23 month age bracket is consistent with that of a study from Uganda [21], which showed that child age (6 to 23 months) was significantly associated with anaemia. The Uganda study also revealed that the prevalence of iron deficiency anaemia was highest among the youngest age groups and generally reduced with an increase in the age of the children, similar to results from other past studies [22, 23]. This observation could be explained by the fact that iron stores are generally depleted among children by six months of age while the blood volume doubles from 4 to 12 months after birth. In this way, the dietary sources of iron are very important in keeping up with this rapid rate of red blood cell synthesis, which may give rise to anaemia if the dietary sources are inadequate [4, 5].

Table 4. Univariate and multivariate analyses of the odds of a child aged 24–59 months being anaemic—Tanzania 2015–16.

Characteristics	Unadjusted		Adjusted	
	OR (95% CI)	P-Value	OR (95% CI)	P-Value
<b>Household Factors</b>				
<b>Household Wealth Index</b>				
Richest	1.00			
Richer	0.98 (0.76,1.28)	0.910		
Middle	1.54 (1.18,2.01)	<0.001		
Poorer	1.73 (1.34,2.24)	<0.001		
Poorest	1.86 (1.45,2.38)	<0.001		
<b>Type of residence</b>				
Urban	1.00			
Rural	1.36 (1.14,1.63)	<0.001		
<b>Number of children under 5 years</b>				
None	1.00			
1 to 2	1.07 (0.66,1.72)	0.780		
≥3	2.04 (1.19,3.49)	0.010		
<b>Household Size (grouped)</b>				
1 to 5	1.00			
>6	1.25 (1.09,1.42)	<0.001		
<b>Source of drinking water</b>				
Not improved	1.00			
Improved	0.83 (0.71,0.98)	0.030		
<b>Type of toilet facility</b>				
Improved	1.00			
Unimproved	1.71 (1.41,2.08)	<0.001		
<b>Maternal Factors</b>				
<b>Respondent worked in the last 12 months</b>				
Non-working	1.00			
Working	1.09 (0.91,1.31)	0.330		
<b>Mother's Education</b>				
Secondary	1.00		1.00	
Primary	1.37 (1.10,1.69)	<0.001	1.10 (0.86,1.39)	0.430
No education	2.29 (1.79,2.93)	<0.001	1.54 (1.18,2.00)	<0.001
<b>Mother's age (years)</b>				
15–19	1.00			
20–34	1.12 (0.72,1.74)	0.610		
35–49	1.05 (0.69,1.60)	0.820		
<b>Mother's marital status</b>				
Never in marriage	1.00			
Currently married	1.14 (0.92,1.41)	0.230		
<b>Maternal anaemia</b>				
Non-anaemic	1.00		1.00	
Anaemic	1.87 (1.64,2.14)	<0.001	1.77 (1.54,2.04)	<0.001
<b>Maternal BMI (Kg/m<sup>2</sup>)</b>				
25+	1.00			
18.5–24.9	1.54 (1.31,1.82)	<0.001		
<18.5	1.38 (0.99,1.92)	0.060		
<b>Currently Pregnant</b>				

(Continued)

Table 4. (Continued)

Characteristics	Unadjusted		Adjusted	
	OR (95% CI)	P-Value	OR (95% CI)	P-Value
No	1.00			
Yes	1.19 (0.95,1.50)	0.120		
<b>Taking iron during pregnancy</b>				
No	1.00			
Yes	0.79 (0.63,0.99)	0.040		
<b>Combined mode and place of delivery</b>				
Vaginal	1.00		1.00	
Caesarean section	0.53 (0.37,0.75)	<0.001	0.55 (0.38,0.80)	<0.001
Home	1.52 (1.29,1.78)	<0.001	1.27 (1.09,1.48)	<0.001
<b>Delivery assistance</b>				
Health professional	1.00			
Non-health professional	1.60 (1.39,1.85)	<0.001		
<b>Antenatal Clinical visits</b>				
8+	1.00			
4 to 7	1.59 (0.75,3.37)	0.230		
1 to 3	1.66 (0.79,3.47)	0.181		
None	1.74 (0.84,3.63)	0.137		
<b>Mother read magazine or newspaper</b>				
At least	1.00			
Less than	1.06 (0.88,1.27)	0.520		
Never	1.11 (0.95,1.30)	0.180		
<b>Mother listened to radio</b>				
At least	1.00			
Less than	1.29 (1.09,1.53)	<0.001		
Never	1.42 (1.19,1.71)	<0.001		
<b>Mother watched television</b>				
At least	1.00			
Less than	1.39 (1.11,1.73)	<0.001		
Never	1.60 (1.31,1.96)	<0.001		
<b>Mother power over earnings</b>				
No	1.00			
Yes	0.83 (0.72,0.96)	0.010		
<b>Mother power over household decision making</b>				
No	1.00			
Yes	0.87 (0.75,1.00)	0.050		
<b>Mother autonomy over health care</b>				
No	1.00			
Yes	0.82 (0.71,0.94)	0.010		
<b>Child Factors</b>				
<b>Combined birth interval and birth order</b>				
1st birth rank	1.00			
2nd/3rd birth rank, more than 2 years interval	0.96 (0.80,1.16)	0.720		
2nd/3rd birth rank, less than or equal to 2	1.12 (0.86,1.47)	0.370		
4th birth rank, more than 2 years interval	1.19 (0.98,1.44)	0.070		
4th birth rank, less than or equal to 2	1.26 (0.94,1.67)	0.110		
<b>Sex of child</b>				

(Continued)

Table 4. (Continued)

Characteristics	Unadjusted		Adjusted	
	OR (95% CI)	P-Value	OR (95% CI)	P-Value
Female	1.00			
Male	1.07 (0.94,1.23)	0.280		
<b>Size of baby</b>				
Large	1.00			
Average	0.91 (0.77,1.09)	0.340		
Small	0.95 (0.72,1.25)	0.720		
<b>Stunted</b>				
No	1.00		1.00	
Yes	1.60 (1.38,1.85)	<0.001	1.46 (1.25,1.71)	<0.001
<b>Wasted</b>				
No	1.00			
Yes	1.06 (0.70,1.60)	0.780		
<b>Underweight</b>				
No	1.00			
Yes	1.25 (1.01,1.56)	0.040		
<b>Children &lt;5 slept with bed net</b>				
Yes	1.00			
No	0.90 (0.88, 1.08)	0.210		
<b>Given drugs for preventing worm infestation</b>				
No	1.00		1.00	
Yes	0.73 (0.63,0.84)	<0.001	0.84 (0.72,0.98)	0.030
<b>Fully Vaccinated</b>				
No	1.00			
Yes	1.41 (0.76,2.60)	0.270		
<b>Vitamin A</b>				
No	1.00			
Yes	0.84 (0.73,0.96)	0.020		
<b>Had diarrhoea in the last two weeks</b>				
No	1.00			
Yes	1.11 (0.86,1.41)	0.400		
<b>Had fever in the last two weeks</b>				
No	1.00		1.00	
Yes	1.64 (1.35,1.99)	<0.001	1.61 (1.32,1.95)	<0.001

<https://doi.org/10.1371/journal.pgph.0001258.t004>

In this study, we found that none or low level of maternal education was associated with iron deficiency anaemia in children. Surprisingly, we found that maternal employment was associated with iron deficiency anaemia in children, contrary to findings from previous research from Brazil [24, 25]. Unemployment and low level of education may lead to poor socio-economic status, thus suggesting that better socio-demographic conditions may increase access to better nutrition and health care and, as a consequence, lower the risk of anaemia [13]. Our finding of the association between a low level of maternal education and iron deficiency anaemia is consistent with a past study from Tanzania [13]. A previous study from Tanzania observed that anaemic children had mothers/carers who did not complete primary education [26]. Another previous study from Ethiopia [27] revealed that the education of mothers demonstrated a protective effect on childhood anaemia. This could be explained by the use of improved feeding and childcare practice by educated mothers. This Ethiopian study

Table 5. Univariate and multivariate analyses of the odds of a child aged 6–59 months being anaemic—Tanzania 2015–16.

Characteristics	Unadjusted		Adjusted	
	OR (95% CI)	P-Value	OR (95% CI)	P-Value
<b>Household Factors</b>				
<b>Household Wealth Index</b>				
Richest	1			
Richer	1.02 (0.85,1.23)	0.821		
Middle	1.36 (1.12,1.64)	0.002		
Poorer	1.44 (1.20,1.74)	<0.001		
Poorest	1.60 (1.33,1.91)	<0.001		
<b>Type of place of residence</b>				
Urban	1			
Rural	1.23 (1.06,1.41)	0.005		
<b>Household Size (grouped)</b>				
1 to 5	1		1	
>6	1.22 (1.09,1.36)	<0.001	1.15 (1.02,1.30)	0.022
<b>Source of drinking water</b>				
Not improved	1			
Improved	0.84 (0.74,0.96)	0.013		
<b>Type of toilet facility</b>				
Improved	1			
Unimproved	1.50 (1.29,1.75)	<0.001		
<b>Maternal Factors</b>				
<b>Respondent worked in the last 12 months</b>				
Non-working	1		1	
Working	1.60 (1.33,1.91)	0.001	1.20 (1.03,1.38)	0.013
<b>Mother's Education</b>				
Secondary	1		1	
Primary	1.08 (0.92,1.26)	0.372	1.05 (0.87,1.27)	0.548
No education	1.59 (1.31,1.94)	<0.001	1.46 (1.17,1.84)	0.001
<b>Mother's age (years)</b>				
15–19	1			
20–34	1.60 (1.33,1.91)	<0.001		
35–49	1.60 (1.33,1.91)	<0.001		
<b>Mother's marital status</b>				
Never in marriage	1			
Currently married	1.07 (0.89,1.29)	0.462		
<b>Maternal anaemia</b>				
Non-anaemic	1		1	
Anaemic	1.81 (1.63,2.01)	<0.001	1.86 (1.65,2.09)	<0.001
<b>Maternal BMI (Kg/m<sup>2</sup>)</b>				
25+	1		1	
18.5–24.9	1.60 (1.33,1.91)	<0.001	1.25 (1.08,1.45)	0.002

(Continued)

Table 5. (Continued)

Characteristics	Unadjusted		Adjusted	
	OR (95% CI)	P-Value	OR (95% CI)	P-Value
<18.5	1.60 (1.33,1.91)	0.001	1.12 (0.82,1.51)	0.453
<b>Currently Pregnant</b>				
No	1			
Yes	1.00 (0.81,1.22)	0.980		
<b>Taking iron during pregnancy</b>				
No	1			
Yes	0.94 (0.79,1.11)	0.460		
<b>Combined mode and place of delivery</b>				
Vaginal	1		1	
Caesarean section	0.69 (0.53,0.89)	0.004	0.65 (0.50,0.85)	0.002
Home	1.27 (1.12,1.45)	<0.001	1.15 (1.01,1.32)	0.038
<b>Delivery assistance</b>				
Health professional	1			
Non-health professional	1.31 (1.16,1.48)	<0.001		
<b>Antenatal Clinical visits</b>				
8+	1			
4 to 7	1.72 (0.94,3.12)	0.076		
1 to 3	1.91 (1.06,3.44)	0.031		
None	0.78 (0.65,2.12)	<0.001		
<b>Mother read magazine or newspaper</b>				
At least	1			
Less than	0.94 (0.76,1.17)	0.589		
Never	1.12 (0.93,1.36)	0.245		
<b>Mother listened to radio</b>				
At least	1			
Less than	1.17 (1.02,1.33)	0.022		
Never	1.28 (1.11,1.47)	0.001		
<b>Mother watched television</b>				
At least	1			
Less than	1.29 (1.09,1.53)	0.004		
Never	1.32 (1.14,1.53)	<0.001		
<b>Mother power over earnings</b>				
No	1			
Yes	0.84 (0.74,0.94)	0.002		
<b>Mother power over household decision making</b>				
No	1			
Yes	0.84 (0.75,0.94)	0.003		

(Continued)

Table 5. (Continued)

Characteristics	Unadjusted		Adjusted	
	OR (95% CI)	P-Value	OR (95% CI)	P-Value
<b>Mother autonomy over health care</b>				
No	1			
Yes	0.81 (0.73,0.91)	<0.001		
<b>Child factors</b>				
<b>Combined birth interval and birth order</b>				
1st birth rank	1			
2nd/3rd birth rank, more than 2 years interval	0.84 (0.72,0.97)	0.019		
2nd/3rd birth rank, less than or equal to 2	0.96 (0.78,1.18)	0.723		
4th birth rank, more than 2 years interval	0.98 (0.84,1.14)	0.822		
4th birth rank, less than or equal to 2	0.94 (0.75,1.17)	0.590		
<b>Sex of child</b>				
Female	1		1	
Male	1.14 (1.03,1.26)	0.010	1.14 (1.02,1.27)	0.021
<b>Size of baby</b>				
Large	1			
Average	1.01 (0.88,1.16)	0.785		
Small	1.17 (0.95,1.46)	0.133		
<b>Child's age in Months</b>				
6 to 23	1		1	
24 to 59	3.31 (2.97,3.68)	<0.001	3.66 (3.27,4.10)	<0.001
<b>Stunted</b>				
No	1		1	
Yes	1.26 (1.12,1.42)	<0.001	1.31 (1.14,1.50)	<0.001
<b>Wasted</b>				
No	1			
Yes	1.48 (1.13,1.93)	0.004		
<b>Underweight</b>				
No	1			
Yes	1.22 (1.03,1.45)	0.018		
<b>Children &lt;5 slept with bed net</b>				
Yes	1			
No	0.90 (0.79,1.03)	0.163		
<b>Given drugs for preventing worm infestation</b>				
No	1			
Yes	0.67 (0.59,0.75)	<0.001		
<b>Number of children under 5 years</b>				

(Continued)

Table 5. (Continued)

Characteristics	Unadjusted		Adjusted	
	OR (95% CI)	P-Value	OR (95% CI)	P-Value
None	1			
1 to 2	0.98 (0.63,1.53)	0.930		
≥3	1.75 (1.08,2.85)	0.024		
<b>Fully Vaccinated</b>				
No	1			
Yes	0.99 (0.56,1.74)	0.990		
<b>Vitamin A</b>				
No	1			
Yes	0.87 (0.77,0.97)	0.020		
<b>Had diarrhoea in the last two weeks</b>				
No	1			
Yes	1.56 (1.32,1.85)	<0.001		
<b>Had fever in the last two weeks</b>				
No	1		1	
Yes	1.55 (1.34,1.79)	<0.001	1.44 (1.23,1.68)	<0.001

& = doctor; nurse/midwife/paramedics, family welfare visitor medical assistant/community medical officer/ health assistant

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also observed that the children of mothers with only primary education had comparable levels of anaemia to their counterparts whose mothers were had secondary education or higher. The level of education of mothers has been previously shown to decrease the prevalence of anaemia [28, 29]. The association of childhood iron deficiency anaemia and education may be attributed to the ability of mothers/carers to acquire the required knowledge for adequate health care and nutrition for children.

We found that stunting was significantly associated with iron deficiency anaemia among children aged 24–59 months and 6–59 months (unlike the other nutrition indices of wasting and underweight), in consonance with previous studies from Brazil [30, 31], Burma [32] and Ethiopia [33]. This association may be due to the fact that i) undernourished children are often anaemic, ii) low haemoglobin concentration can compromise linear growth, and iii) the coexistence of other micronutrient deficiencies and stunting may increase the development of anaemia by a synergistic association. Consequently, efforts geared towards preventing stunting in children may also contribute to reducing the iron deficiency anaemia menace in children.

Small-sized children (low birth weight) aged 6–23 months were found to be associated with anaemia in this study. This finding is corroborated by previous findings from Tanzania [34] and Malawi [35]. Although low birth weight has been strongly associated with maternal iron deficiency anaemia [36, 37], which negatively impacts a child's iron store at birth, a clear association between baby size and anaemia has not been established.

Our current study revealed an association between childhood iron deficiency anaemia and low socio-economic status. In spite of a dearth of data in the extant literature which identifies the risk factors for iron deficiency anaemia in children aged less than two years, past studies have observed that socio-economic and environmental factors appear to be closely associated with iron deficiency anaemia among these children [32, 33, 38]. Children with mothers from

poor households had a statistically significant increased level of childhood anaemia. This finding has also been demonstrated in similar studies [28, 29].

In this study, we found a significant association between anaemic mothers and childhood iron deficiency anaemia. This finding is consistent with other past studies [39]. In addition, there is evidence of an association of maternal iron deficiency during pregnancy and lactation and iron deficiency in young children [39]. Furthermore, a study conducted in India [39] revealed that severe maternal iron deficiency anaemia can adversely affect cord blood and breast milk iron status, which may lead to serious consequences for the young infant at a time when demands for iron are high. Furthermore, evidence from the extant literature suggests that maternal iron deficiency may compromise maternal cognitive and interactive behaviours, which could influence the child's care [40]. Consequently, it is important to ensure adequate maternal nutritional status during this important period which favours adequate development of young children.

Our study revealed that being a male child was significantly associated with increased odds of childhood iron deficiency anaemia. This finding is consistent with previous studies from Kenya [41, 42]. A similar finding was made in another study from Ghana [43]. Greater attention should be given to male children in terms of dietary diversity and iron-rich complementary foods.

Evidence in this study that was mentioned above, the prevalence suggests the occurrence of iron deficiency anaemia among children aged 6 to 59 months as severe public health, in turn associated with either proximal or distal determinants. The nutrition-specific approach mainly targeting the immediate/proximal determinants and, can be delivered through education, communication, social marketing, and behaviour changing programs to target specific groups, and in young children, they are frequently oriented to improve age adequate breastfeeding, dietary diversity, and feeding frequency [2, 44]. Conversely, a nutrition-sensitive approach is targeting fundamental/distal determinants from a wide range of sectors, comprising disease control, water, sanitation, and hygiene and inter-sectoral strategies that address root causes (e.g., poverty, lack of education, and gender norms) [2, 44]. Therefore guiding future strategies targeting nutritional anaemia among children aged 6 to 59 months in Tanzania should be combined; Integrating strategies on preventive (either nutrition-based or WASH/ malaria education) and therapeutic (deworming) could result in the reduction of anaemia [2, 44]. For instance, deworming plus nutrition education has been reported to reduce anaemia from 82.0% to 55.4%, while increasing green leafy vegetable consumption from 44.7% to 60.6%.40 Furthermore, exclusive educational interventions targeting nutrition improvement; the increased ability of mothers to identify malnutrition (from 15% to 99%); exclusive breastfeeding (79% compared to 48% in control); weight gain (0.86 compared to 0.77 kg in control); vegetables feeding; nutrient-dense foods at lunch (11% of the difference between intervention and control groups); dietary requirements for energy, iron, and zinc; complementary feeding; and significantly reduced rates of stunting [45–47].

One of the important strengths of this study is that the 2015–16 TDHS is nationally representative and used a standardised method to achieve a high response rate, which meant that the findings in the study would be devoid of sampling bias in Tanzania. However, the study is not without limitations, which should be considered when interpreting the results of the study. Firstly, the cross-sectional nature of this study is a potential limitation because this kind of study does not allow inference of causality, and results must thus be interpreted carefully. Secondly, despite the WHO recommendation in 2014 on delayed umbilical cord clamping and cutting to reduce the risk of anaemia and hypoxia in infants, however, its implementation is still low in many countries including Tanzania [48, 49]. Thirdly, haemolytic anaemia attributed by thalassemia and other haemoglobinopathies was not part of this study as it was not assessed in the 2015–16 TDHS. Although the occurrence of haemoglobinopathies in Tanzania

fulfils the World Health Organization criteria of public health importance, this problem is often overlooked. For instance, no country in sub-Saharan Africa has even established a national universal newborn screening (NBS) programme [11] and lastly, this study used MDD-7, meaning the proportion of children aged 6–23 months who consumed  $\geq 4$  of 7 food groups instead of  $\geq 5$  of 8 food groups (MDD-8) as reported in [50]. However, a recent study conducted in the Eastern and Southern Africa region by Heidkamp et al. [51] that compared the prevalence of MDD-8 and MDD-7 revealed that confidence Intervals around the prevalence estimates for MDD-7 [OR25.6%; 95%CI: 23.4, 27.9] and MDD-8 [OR 20.2%; 95%CI: 18.7, 22.7] overlapped for Tanzania [51].

## Conclusions

Childhood anaemia in Tanzania is a significant public health problem. A higher degree of maternal anaemia predisposes to childhood iron deficiency anaemia. Low maternal level of education and low household economic status were found to be associated with iron deficiency anaemia in children. Identifying the root cause of iron deficiency anaemia in children and improving nutritional advice and supplementation will be required. Prospective cohort studies on haemoglobinopathies contribution to be burden of childhood anaemia may be an important field for future research. It is important to develop public health interventions with a holistic approach to mothers and children. Efforts to deliver the Sustainable Development Goals meant to improve education for women and eradicate poverty also have the likelihood of leading to significant reductions in childhood iron deficiency anaemia.

## Supporting information

**S1 Table. Definition and categorisation of potential variables used in the study.**  
(DOCX)

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