ORIGINAL RESEARCH ARTICLE

Maternal micronutrient status as a risk factor for perinatal mortality in a Tanzanian randomized controlled trial

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Abstract

The objective of this study was to determine if maternal micronutrient status (specifically iron) during pregnancy is a risk factor for perinatal mortality among women in Tanzania. Secondary analysis of data from a randomized, double-blind, placebo-controlled vitamin A supplementation trial conducted between August 2010-March 2013 was used to assess iron intake among women who experienced a stillbirth or early neonatal death. The mean dietary iron intake (measured using a quantitative Food Frequency Questionnaire) for this population was 12.64 mg/day (SD = 6.32). There were 206 cases of perinatal mortality. Three classifications of dietary iron intake were devised and risk ratios were calculated using the Log Binomial Regression Model: <18 mg/day (RR: 2.13), 18-27 mg/day (RR: 2.63), & >27 mg/day (the reference group to which the first two classification groups were compared). There was neither a significant relationship found among women who consumed iron levels <18 mg/day or between 18-27 mg/day of iron compared to women who consumed more than 27 mg/day of iron, but on average there was twice the risk for perinatal mortality. The current study is consistent with previous literature findings and supports the need for more efficacious nutrition strategies. *(Afr J Reprod Health 2022; 26[7]: 38-48).*

Keywords: Maternal nutrition, perinatal mortality, iron intake, Tanzania

Résumé

L'objectif de cette étude était de déterminer si le statut maternel en micronutriments (en particulier le fer) pendant la grossesse est un facteur de risque de mortalité périnatale chez les femmes en Tanzanie. Une analyse secondaire des données d'un essai randomisé, en double aveugle et contrôlé par placebo sur la supplémentation en vitamine A menée entre août 2010 et mars 2013 a été utilisée pour évaluer l'apport en fer chez les femmes ayant subi une mortinaissance ou un décès néonatal précoce. L'apport alimentaire moyen en fer (mesuré à l'aide d'un questionnaire quantitatif sur la fréquence alimentaire) pour cette population était de 12,64 mg/jour (ET = 6,32). Il y a eu 206 cas de mortalité périnatale. Trois classifications de l'apport alimentaire en fer ont été conçues et les risques relatifs ont été calculés à l'aide du modèle de régression binomiale log : <18 mg/jour (RR : 2,13), 18-27 mg/jour (RR : 2,63) et >27 mg/jour (le groupe de référence auquel les deux premiers groupes de classification ont été comparés). Il n'y avait aucune relation significative trouvée entre les femmes qui consommaient des niveaux de fer <18 mg/jour ou entre 18 et 27 mg/jour de fer par rapport aux femmes qui consommaient plus de 27 mg/jour de fer, mais en moyenne il y avait deux fois plus de risque pour la mortalité périnatale. L'étude actuelle est conforme aux conclusions de la littérature précédente et soutient la nécessité de stratégies nutritionnelles plus efficaces. *(Afr J Reprod Health 2022; 26[7]: 38-48).*

Mots-clés: Nutrition maternelle, mortalité périnatale, apport en fer, Tanzanie

Introduction

An estimated 2.4 million newborns died within their first month of life globally in 2019[1]. In 2019, the highest number of newborn deaths occurred in India (522,000), Nigeria (270,000), and Pakistan (248,000)[1]. The most common causes of neonatal mortality, defined as the death of a newborn within 28 days of a live birth, include preterm birth, intrapartum-related complications, birth defects, and infections[1]. Early neonatal deaths, defined as the death of a newborn within seven days of a live birth, account for three-quarters of these deaths[2]. The majority (80%) of early neonatal deaths occur between birth and 3 days of life[3]. The most common contributing factors to early neonatal death include prematurity, congenital anomalies, and asphyxia[3,4]. Developing countries also experience disproportionately higher rates of stillbirths, defined as a baby born with no signs of life at or after 28 weeks gestation[5]. In 2015, 2.6 million stillbirths occurred globally, three-quarters of these deaths occurring in sub-Saharan Africa and south Asia. In sub-Saharan Africa, 825,000 stillbirths occurred in 2019, compared to the lowest number of combined recorded deaths in Europe, Northern America, Australia and New Zealand (39,000)[6]. The most common maternal factors that increase the risk for stillbirth include smoking, alcohol consumption, diabetes, multiparity, and increased maternal age[7]. Tanzania holds the second highest number of neonatal deaths (43,000) in sub-Saharan Africa[1]. Asphyxia, neonatal respiratory distress, prematurity, and neonatal sepsis account for the main causes of early neonatal deaths[8]. Additionally, there were 40,500 reports of stillbirths in 2019[9]. The most common causes for stillbirth in Tanzania are preeclampsia and placental abruption[10].

Maternal nutrition

Nutritional status during pregnancy

Recent studies have focused on maternal nutritional status as a predictor of birth outcomes and early neonatal mortality. Maternal malnutrition, including micronutrient deficiency, has been attributed to infants small for gestational age, infants born of low birth weight, and infant mortality and morbidity[11,12]. Pregnant women are at particularly higher risk for micronutrient deficiencies because stored and ingested nutrients function primarily to support the growth and development of the fetus[13].

Dietary reference intakes

The Food and Nutrition Board, Institute of Medicine, National Academies Press developed Dietary Reference Intakes (DRIs) to provide nutrient intake guidelines for individuals to assess and plan diets for a healthy population. DRIs are composed of five sets of reference values, including the Recommended Dietary Allowance (RDA) which is the most relevant guideline for this study. RDAs are the intake levels that meet the need for 97-98% of individuals in a life stage or gender group. RDAs are set for vitamins, minerals, and energy nutrients (fats, carbohydrates, and protein)[14]. For the purpose of this study, the RDAs of important vitamins and minerals for maternal health to maintain metabolic processes are indicated in Table 1.

Macronutrients and maternal health outcomes

Macronutrients provide the body with the required calories or energy to maintain and carry out daily body functions[14]. Macronutrients are required in large amounts and are classified into three broad categories: fat, carbohydrates, and protein. During pregnancy, there is an increase in the amount of energy needed to support metabolic functions and tissue building[14]. Fat needs can be met through long-chain polyunsaturated essential fatty acids (LC-PUFAs), which are important during pregnancy to promote proper development of the fetal brain and retina. LC-PUFAs can be supplied through food sources or synthesized through omega 3 and omega 6 fatty acid families. These fatty acids can be found in fatty fish, flaxseeds, nuts and oils such as canola, sunflower, and soybean.

Carbohydrates are essential for providing the body with energy and sparing the body's fat and protein stores. This energy is not only used by the mother but also benefits the growing fetus. Carbohydrates also prevent the body's protein stores from being converted to glucose and ensure the protein can be used for growth and tissue repair[14].

Protein is required for maternal tissue growth and the development of fetal tissue[15]. The mother needs protein for the enlargement of the uterus for proper fetal growth, the formation of the amniotic sac, the increased production of blood that will be lost during delivery, and in preparation for lactation. Protein needs can be met through the consumption of lean meat, low-fat milk, seafood, and plant derived foods[15].

Micronutrients and maternal health outcomes

Micronutrients are the vitamins and minerals needed by the body in small amounts to maintain metabolic processes and have been linked to fetal development outcomes[14].

Vitamins

Vitamin A, in safe doses, aids with proper eyesight, immune system function[16], and supports fetal growth and tissue maintenance[17]. Iodine is essential for fetal growth and cognitive development[17]. Vitamin D plays an important role in the development of the skeleton and deficiencies can cause fetal bone abnormalities. Vitamin B_{12} is concentrated in the placenta as newborn levels of B12 are often twice that of maternal levels. Vitamin B_{12} is stored in the fetal liver and provides stores to maintain the newborn through their first few months of life. Foods rich in Vitamin B_{12} include milk, cheese, eggs, fish, meat, and poultry. There are no plant-based sources of Vitamin B_{12} so vegetarians and vegans are at particularly higher risk for Vitamin B_{12} deficiency. Fortified foods and supplements can be used to meet the need for Vitamin B_{12}[14]. Folate is essential for healthy development of the spine and brain and proper red blood cell development. Folate also helps with cell multiplication, which is imperative during stages of rapid cell division, such as the embryonic and fetal stages of pregnancy[18]. Folic acid supplementation prior to conception has been attributed to the reduction of risk for neural tube defects[19].

Minerals

Zinc is important for protein synthesis and cell development and can be found in protein rich foods such as meat, nuts, and shellfish[15]. Calcium plays an important role in the development of the fetal skeleton and is found in milk, yogurt, cheese, and calcium-fortified foods such as cereals and soy milk[15]. Maternal bones store calcium and the internal absorption of calcium doubles early during pregnancy. Adequate calcium intake is recommended to meet fetal needs and preserve maternal bone mass. Iron is important for the production of red blood cells, muscle cells, and proper brain development in the fetus[20]. Daily oral iron supplementation between 30-60 mg is recommended for pregnant women to prevent maternal anemia, preterm birth, and low birthweight infants[21].

Iron deficiency anemia is prevalent in pregnant women because the need for iron increases drastically, yet maternal dietary intake of absorbable iron often does not increase[18]. Iron deficiency is most commonly attributed to iron-poor diets and the lack of food in general. Non-diet associated causes of deficiency occur in regions with parasitic infections of the gastrointestinal tract[15]. In order to prevent iron-deficiency, one must consume foods that are good sources of iron. There are two forms of iron: heme and nonheme. Heme iron is found in meat, poultry, and fish and is much more absorbable than nonheme iron. Nonheme iron accounts for the majority of iron consumed by most people and is found in vegetables, eggs, meat, grains, fish, and poultry.

Prenatal vitamins typically include increased amounts of folate, iron, vitamin D, and calcium, which are especially important for women with inadequate diets[15]. Pregnant women must consume an increased amount of these nutrients for the proper development and growth of the fetus. When micronutrient needs are not met by the mother, subsequently, these nutrients are not transferred to the fetus which can result in severe health and development consequences. To ensure pregnant women are consuming a sufficient amount of micronutrients, quantitative tools can be used to identify deficiencies through the measurement of dietary diversity and food frequency.

Dietary diversity

Dietary diversity[23] is defined as the number of varying foods and food groups that are consumed over a given period and is often the proxy for high quality diets. A diverse diet is sufficient in appropriate levels of lean meat, fish, eggs, vegetables, and fruits can supply the body with these essential nutrients. Dietary Diversity Scores (DDS) can be calculated and used to determine the extent to which one’s diet is diverse and the accessibility of various food items and food groups. DDS are generated by counting the number of food groups an individual consumes over a given reference period, which is usually between 24 hours and seven days[24].

Food frequency

Food composition tables and Food Frequency Questionnaires (FFQ) are useful measurement tools that provide information about diets at the population and individual level. The Tanzania Food Composition Tables[25] were developed in 2008 with the intention of calculating the value of the amount of energy and nutrients (e.g., fat, protein, and vitamins) a food item contains. FFQs collect dietary data using a context-specific food list to estimate an individual's usual diet over a given reference period, which is usually the past month or year. Data can be collected on the consumption of specific foods and specific micronutrients (e.g., iron, vitamin A, folic acid[24] in a population and can also determine the extent to which a diet is diverse. This study suggests that in addition to diet diversity, diet quality is strongly associated with improved birth outcomes.

Nutritional status of women in tanzania

The traditional diet in Tanzania consists of cereals, roots, maize, plantain, rice, potatoes, and cassava. Other foods such as yams, sweet potatoes, and millet are also consumed but at lesser rates. Vegetables are consumed frequently but fruits are consumed less frequently. This diet is primarily composed of starchy foods with high fiber content. It is important to recognize there are some ethnic groups that adhere to different diets, however, most Tanzanians will consume a minimally diverse diet based on availability and economic status[26].

Tanzania faces the very prevalent issue of undernutrition, a few nutrition related conditions including protein-energy malnutrition and micronutrient deficiencies[27]. In Tanzania, about 45% of women of reproductive age (between 15–49 years) are anemic and 57.1% of pregnant women are anemic[28]. Only 21% of women took iron supplements or syrup for 90 days or more as recommended during their pregnancy[28]. Additionally, about 33.9% of Tanzanians experience low mean dietary energy intake[29]. Other contributing factors include an insufficient availability of diverse foods and poor food utilization due to a lack of dietary knowledge.

Maternal nutritional status and birth outcomes

Populations that are undernourished are often deficient in micronutrients that are necessary for fetal growth and development[30]. Animal source foods are also great sources of vitamin A, vitamin B-12, riboflavin, calcium, iron, and zinc. Therefore, pregnant women in countries lacking diverse diets and consumption of meat will experience micronutrient deficiencies[31]. Maternal malnutrition has clearly been linked to adverse birth outcomes. Higher food quality scores have been associated with lower risk for preterm births, infants of low birth weight, and fetal loss[32]. Additionally, more diverse diets have been associated with lower rates of infants born small for gestational age. Despite this clear relationship, there is still a gap in knowledge about the association between maternal nutritional factors and perinatal mortality, defined as the number of stillbirths and deaths within seven days of a live birth[1].

A study was conducted in Tanzania to evaluate the relationship between micronutrient supplementation on infant mortality[33]. Maternal nutritional status data was collected in this study and will be used to direct the current study. The goal of the current study is to evaluate the relationship between maternal micronutrient status, specifically iron intake, and perinatal mortality among pregnant women in Tanzania. Iron was chosen due to the high prevalence of anemia during pregnancy among Tanzania women and the potential effects this micronutrient deficiency can have on fetal development.

Methods

Original study

The original study of Masanja *et al.*, (2015) in Dar es Salaam in Tanzania evaluated maternal risk factors using outcome data from infants and mothers who were enrolled in the randomized, double-blind, placebo-controlled vitamin A supplementation trial. The purpose of this study was to determine if supplementation of 50,000 IU of Vitamin A within 2-3 days of birth reduces the risk for infant death before six months of life. Participants were pregnant women and infants who were screened and recruited during antenatal clinic visits or labor units of public health facilities in Dar es Salaam between August 2010-March 2013. A total of 31,999 infants were randomly assigned to receive either one dose of 50,000 IU of vitamin A (n=15,995) or a placebo (n=16,004) in the first 3 days after birth. This study found no significant effect of vitamin A supplementation on infant mortality within the first six months of life, compared to the placebo group.

Adverse events after the vitamin A dose were monitored by trained field interviewers. Field interviewers also conducted home visits after 1, 3, 6, and 12 months, to monitor the vital status of the infant including any reports of morbidity requiring hospitalization. Reports of infant deaths were investigated, and field interviewers visited families after the deaths to conduct verbal autopsy interviews. The study was approved by the IRBs of Harvard T.H. Chan School of Public Health, Ifakara Health Institute, & Medical Research Coordinating Council of Tanzania. The WHO Ethical Review Committee approved this study protocol.

The current study

Secondary data analysis

Secondary analysis of data from the Masanja *et al.*, (2015) study was conducted in the current study to evaluate the relationship between maternal nutritional status and perinatal mortality. The data and measures used from the aforementioned study will be discussed below. The primary outcome of interest was perinatal mortality, defined as the number of stillbirths, defined as babies born with no signs of life at or after 28 weeks of gestation[5], and early neonatal deaths, defined as death of a newborn within seven days of birth[2]. The central unit of analysis is the maternal micronutrient status during pregnancy, specifically iron intake.

Participants

Participants were mothers of singleton pregnancies, 15 years of age and older, with a completed a Food Frequency Questionnaire (FFQ) and a birth outcome of either stillbirth or early neonatal death (n=206). Research staff administered the FFQs, in either English or Swahili, to participants during enrollment in the study. Research staff conducted follow-up at the participant's home to determine infant status. Stillbirths will be identified through field interviewer data asking participants of the outcome of their pregnancy, if they were no longer pregnant. Participants could indicate if the pregnancy ended in stillbirth and only these cases will be included in the analysis. Early neonatal deaths will be identified through field interviewer data indicating the "infant status" as deceased and only cases of date within 7 days of live birth will be included in the analysis.

Variables and measures

Nutrient intake was assessed through a FFQ. Women were asked the question "How often have you eaten the following foodstuffs during the last month" and indicated if they consumed the list of 108 food items never, 1 time per month, 1-3 times per month, 1 time per week, 2-4 times per week, 5-6 times per week, 1 time per day, 2-3 times per day, 4-5 times per day, or 6+ times per day.

Women were also asked about their monthly consumption of seasonal foods and specific ingredients as well as which grain they used for porridge and the portion size of particular foods that are added to the family pot each day. FFQs use context specific food lists and usually use longer recall periods. This is useful to understand the relationship between usual food consumption patterns and health outcomes[34]. The FFQ was used to estimate micronutrient intake (i.e., iron consumed through specific food items) and compute mean nutrient intake scores over a one month period. The average daily servings was calculated and translated into nutrient intake based on the Tanzania Food Composition Tables. Nutrient intake was calculated with this table by multiplying the nutrient figure by the weight of the food consumed (nutrients are expressed per 100g or 100 mL)[25].

Statistical analysis

The primary hypothesis tested in the current study was: 1) Micronutrient intake, specifically iron, and food frequency during pregnancy will be a predictor of early neonatal deaths and stillbirths. Log Binomial Regression Models were used to assess the relationship between maternal nutritional status and perinatal mortality. Results of importance included p-values less than 0.05, within a 95% confidence interval.

Three classifications of dietary iron intake were devised: <18 mg/day, 18-27 mg/day & >27 mg/day. Generalized Linear Models were used to compare the iron groups among the cases of perinatal mortality. Risk ratios will be used to estimate the risk for stillbirth and early neonatal death among women with higher versus lower iron micronutrient intake levels. The statistical software used for data analysis was STATA version 16.1.

Results

A total of 8,788 women had complete Food Frequency Questionnaire data. The mean dietary iron intake was 12.64 mg/day; SD = 6.32 (Figure 1).

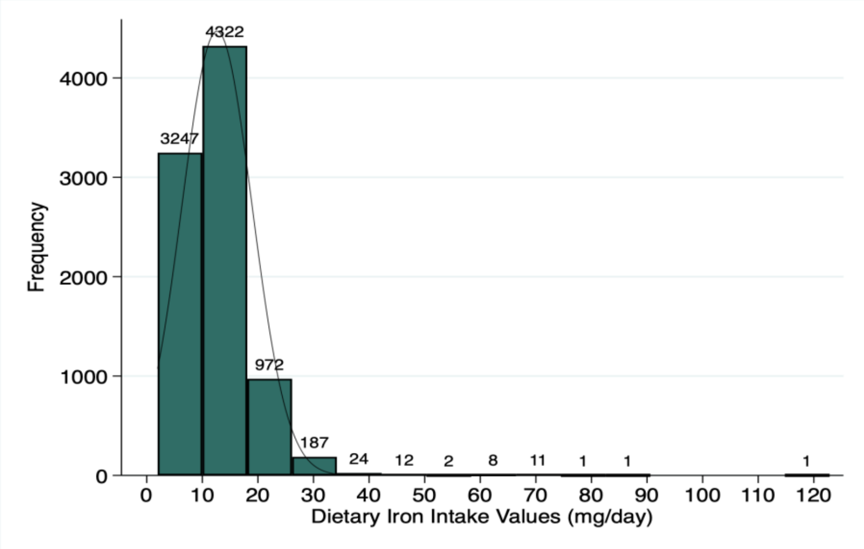

Figure 1: Histogram of Dietary Iron Intake Value (n=8,788)

Table 1: Recommended Dietary Allowance (RDA) for vitamins and minerals for women of various age groups

Age (years)	Vit A (µg/ day)	Vit B12 (µg/ day)	Vit C (mg/ day)	Vit D (µg/ day)	Folate (µg/ day)	Iodine (µg/ day)	Zinc (mg/ day)	Calcium (mg/ day)	Iron (mg/ day)
≤18	750	2.6	80	15	600	220	12	1300	27
19-30	770	2.6	85	15	600	220	11	1000	27
31-50	770	2.6	85	15	600	220	11	1000	27

Source: Adapted from the Dietary Reference Intake series (2011). Food and Nutrition Board, Institute of Medicine, National Academies Press[22].

Table 2: Baseline demographics and health characteristics of mothers (n=8,788)

	Dietary Iron Intake (n = 8,788) n (%)		
	Less than RDA for females 19-50 years (18 mg/day)	Between RDA for females and RDA during pregnancy (18-27 mg/day)	Greater than RDA for pregnancy (27 mg/day)
Maternal Characteristics	(n=7,547)	(n=1,056)	(n=185)
Maternal age, years			
15-17	182 (2.4%)	18 (1.7%)	2 (1.1%)
18-25	3,527 (46.7%)	505 (47.8%)	85 (45.9%)
26-33	2,691 (35.7%)	388 (36.7%)	70 (37.8%)
34-39	732 (9.7%)	83 (7.9%)	21 (11.4%)
40+	158 (2.1%)	27 (2.5%)	2 (1.1%)
Missing	257 (3.4%)	35 (3.3%)	5 (2.7%)
Maternal education			
None	589 (7.8%)	76 (7.2%)	9 (4.9%)
Primary 1-7 yrs	6,289 (83.3%)	899 (85.1%)	159 (85.9%)
Secondary 8-12 yrs	439 (5.8%)	51 (4.8%)	16 (8.6%)
Higher than 13 yrs	24 (0.3%)	0 (0%)	0 (0%)
NA	206 (2.7%)	30 (2.8%)	1 (0.5%)
Frequency of antenatal care (# of visits)			
None	88 (1.2%)	7 (0.7%)	1 (0.5%)
1-4	5,423 (71.9%)	779 (73.8%)	138 (74.6%)
5-8	373 (4.9%)	55 (5.2%)	16 (8.6%)
9+	15 (0.2%)	2 (0.2%)	1 (0.5%)
NA/missing	1,648 (21.8%)	213 (20.2%)	29 (15.7%)
Household Wealth Quintile			

First	1,143 (15.1%)	186 (17.6%)	28 (15.1%)
Second	2,227 (29.5%)	331 (31.3%)	56 (30.3%)
Third	1,937 (25.7%)	231 (21.9%)	46 (24.9%)
Fourth	692 (9.2%)	92 (8.7%)	16 (8.6%)
Fifth	1,220 (16.2%)	165 (15.6%)	37 (20.0%)
Missing	328 (4.3%)	51 (4.8%)	2 (1.1%)
Gravidity			
0	64 (0.8%)	9 (0.9%)	1 (0.5%)
1-3	4,415 (58.5%)	654 (61.9%)	114 (61.6%)
4-6	1,464 (19.4%)	173 (16.4%)	35 (18.9%)
7-9	293 (3.9%)	42 (4.0%)	10 (5.4%)
10+	21 (0.3%)	2 (0.2%)	0 (0%)
NA	1,290 (17.1%)	176 (16.7%)	25 (13.5%)

The mean maternal age was 25.99 years (SD = 6.00). The majority of mothers (85.52%) only completed primary education between 1-7 years. The mean number of visits to antenatal care was 2.94 (SD = 1.14). Household socioeconomic status was stratified by wealth quintiles, first through fifth, corresponding to the poorest 20% of the participants through the wealthiest 20% of the participants. The majority of women were in the second (31.09%) and third quintiles (26.34%). The mean number of times women had been pregnant was 2.80 (SD=1.92) (Table 2).

Three classifications of dietary iron intake were devised based on RDA levels for this population. The RDA of iron for females between the ages of 19-50 years is 18 mg/day and the RDA for pregnant females between the ages of 19-50 is 27 mg/day. The first cutoff group was for dietary iron intake less than the RDA for females 19-50 years old (<18 mg/day), the second cutoff group was between the RDA for females 19-50 years and the RDA for pregnant females 19-50 years old (18-27 mg/day), and the third cutoff group was for greater than the RDA for pregnant females 19-50 years old (>27 mg/day). The latter cutoff group served as the reference group to which the first and second cutoff groups were compared. Among the total number of participants included in this study, 7,547 (85.88%) women consumed <18 mg/day of iron, 1,056 (12.02%) women consumed between 18-27 mg/day of iron, and 185 (2.11%) women consumed >27 mg/day of iron (Table 2).

Perinatal mortality and deaths within seven days of a live birth, affected 206 (2.34%) participants in this study. When stratified by iron group classification, 84.47% of the cases were among mothers who consumed less than 18 mg/day of iron, 14.56% of the cases were among mothers who consumed between 18-27 mg/day of iron, and 0.97% of the cases were among mothers who consumed greater than 27 mg/day of iron (Table 3).

Women who consumed less than 18 mg/day of iron had 2.13 times the risk of perinatal mortality compared to those who consumed more than 27 mg/day of iron (95% CI 0.53-8.53). Additionally, women who consumed between 18-27 mg/day of iron had 2.63 times the risk of perinatal mortality compared to those who consumed more than 27 mg/day of iron (95% CI 0.63-10.90) (Table 4).

The model was adjusted for maternal age, maternal highest level of education, frequency of antenatal care, and household socioeconomic status in wealth quintiles. Women under the age of 26 years had a 6.74% reduction in risk of experiencing perinatal mortality compared to women older than 26 years of age (95 % CI 0.69-1.26). Women who completed either primary education or no education at all had a 22.43% reduction in risk of experiencing perinatal mortality compared to women who completed secondary education or higher (95 % CI 0.46-1.31). Women who never sought antenatal care had a 29.18% reduction in risk of experiencing perinatal mortality compared to women who sought antenatal care 4 or more times (95 % CI 0.10-5.17). Additionally, women who sought antenatal care 1-3 times had a 18.92% reduction in risk of experiencing perinatal mortality compared to women who sought antenatal care 4 or more times (95 % CI 0.51-1.28). Women in the first through third wealth quintiles had 1.83 times the risk of experiencing perinatal mortality compared to women who were in the fourth or fifth wealth quintiles (95 % CI 0.46-1.31, P-value = 0.001) (Table 4).

Discussion

The current study aimed to examine the association between maternal nutritional status (i.e., iron

Table 3:.Baseline demographics and health characteristics of infants (n=8,788)

	Dietary Iron Intake n (%) Less than RDA for females 19-50 years (18 mg/day)	Between RDA for females and RDA during pregnancy (18-27 mg/day)	Greater than RDA for pregnancy (27 mg/day)
Infant Characteristics			
Infant Sex (n=8,788)			
Male	4,077 (46.4%)	535 (6.1%)	91 (1.0%)
Female	3,470 (39.5%)	521 (5.9%)	94 (1.1%)
Ending of Pregnancy (n=8,788)	7,434 (84.6%)	1,033 (11.8%)	183 (2.1%)
Live Birth	113 (1.3%)	23 (0.3%)	2 (0.02%)
Stillbirth			
Age of Death (n=287)			
Less than 7 days	65 (22.6%)	8 (2.8%)	0 (0%)
8+ days	189 (65.9%)	22 (7.7%)	3 (1.0%)
Perinatal Mortality (n=8,788)			
Yes	174 (2.0%)	30 (0.3%)	2 (0.02%)
No	7,373 (83.9%)	1,026 (11.7%)	183 (2.1%)

Table 4: The effect of mean dietary iron intake on perinatal mortality (stillbirths and early neonatal deaths)

	Number of infants		Risk Ratio (95% CI)	P Value	Adj Risk Ratio (95% CI)	P Value
	N (deaths)	N (total # of infants)				
Iron Intake less than 18 mg/day	174	7,547	2.13 (0.53, 8.53)	0.28	1.84 (0.48, 7.04)	0.38
Iron Intake between 18-27 mg/day	30	1,056	2.63 (0.63, 10.90)	0.18	2.35 (0.59, 9.33)	0.23
Iron intake greater than 27 mg/day	2	185	-	-	-	-
Age Group, years						
15-25	78	4,241	0.90 (0.66, 1.22)	0.485	0.93 (0.69, 1.26)	0.65
26+	84	4,088	-	-	-	
Mother Education						
None & Primary	185	7,836	0.87 (0.51-1.49)	0.62	0.78 (0.46, 1.31)	0.35
Secondary & More than 13 years	14	516	-	-	-	-
Frequency of Antenatal Care						
None	1	95	0.72 (0.10-5.24)	0.75	0.71 (.10, 5.17)	0.73
1-3 times	59	4,949	0.81 (0.51-1.29)	0.38	0.81 (0.51, 1.28)	0.37
4+ times	26	1,768	-	-	-	-
Household Wealth Quintile						
First-Third	159	6,026	1.54 (1.08, 2.20)	0.02	1.83 (1.28, 2.62)	0.001
Fourth-Fifth	37	2,185	-	-	-	-

micronutrient dietary intake) and perinatal mortality among pregnant women in Tanzania. There was no significant relationship found among women who consumed iron levels less than the RDA for women 19-50 years old, but on average this group had two times the risk, compared to women who consumed more than the RDA for pregnant women 19-50 years old. Similarly, there was no significant relationship found among women who consumed iron levels between the overall RDA for women 19-50 years old and specifically pregnant women 19-50 years old, but on average this group had two times the risk, compared to women who consumed more than the RDA for pregnant women 19-50 years old. Women in higher wealth quintiles had a reduced risk for perinatal mortality. A significant relationship was found among mothers in the first through third wealth quintiles being at 1.54 times the risk for perinatal mortality compared to women of higher household economic status. After adjusting for maternal age, maternal education, frequency of antenatal care, and household socioeconomic status, there were still no significantrelationships found among the three iron intake levels and perinatal mortality outcomes.

This study sheds light on the scarcity of studies investigating the relationship between micronutrient intake, specifically iron, and perinatal mortality. The findings of this study are consistent with other studies that have assessed the risk for stillbirths and neonatal death among varied daily iron intake groups. Women who consume greater than 14.70 mg/day of iron had a 34% reduction in risk of experiencing a stillbirth compared to women who consumed less than 9.30 mg/day of iron. Additionally, women who consumed greater than 14.70 mg/day of iron had a 19% reduction in risk of experiencing a neonatal death compared to women who consumed less than 9.30 mg/day of iron[35].

The findings from the current study also suggest the need for increased consumption of iron either through diet or supplementation. Inadequate amounts of iron is a major contributing factor for anemia, the condition in which the number of red blood cells or the hemoglobin concentration within them is less than normal[36]. Anemia during pregnancy is associated with significantly higher rates of preterm birth, infants born small for gestational age, and perinatal mortality[37]. Specifically, maternal anemia can result in 1.51 times the risk of perinatal mortality[38]. The burden of anemia among pregnant women has remained prevalent at 57.1% in Tanzania, and particularly affects women less than 19 years of age and greater than 40 years of age, women with no education or only primary education, and women below the middle wealth index[39].

While this study helped to advance the field of maternal nutrition and perinatal mortality specifically in Tanzania, there were some limitations. The sample size was too small to find significance within the three dietary iron intake groups, which is evident by the wide confidence intervals for each group. Additionally, the value of 1 lies within the confidence intervals, therefore there is insufficient evidence to suggest the difference between these groups is statistically significant.

Conclusion and recommendations

This study serves as an initial contribution to research investigating the influence of micronutrient status on perinatal mortality by attempting to provide more understanding of the relationship between maternal iron status and pregnancy outcomes. Further research studies can contribute to this area of study by incorporating a larger, diverse sample size of mothers from Tanzania to understand this population more in-depth and implement policies and protocols to address their nutritional needs.

Future public health efforts should focus on the potential risk factors for perinatal mortality, including maternal education, frequency of antenatal care, and household socioeconomic status. Nutrition programs should be developed to increase access to diverse food items and meals and increase efforts to disperse micronutrient supplementation. It is also important to focus attention on ensuring girls and women stay in school, advocating for women to receive routine, high quality antenatal care as well as maternal and child health education. The Government of Tanzania is responsible for establishing priorities and targets associated with maintaining sufficient nutritional status. Their 2015 National Nutrition Strategy target was to increase maternal iron supplementation during the first three months of pregnancy from 10%-30%[25]. The 2015-2016 Tanzania Demographic and Health Survey and Malaria Indicator Survey found in addition to the risk of not consuming iron sufficient foods, only one fifth of pregnant women were consuming iron supplements[25]. These findings support the need for increased behavior changes among pregnant women, the provision of increased iron supplementation services, and potentially a wider array and availability of iron fortified foods in Tanzania.

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