BMC Pediatrics

RESEARCH

Open Access

Nutritional rickets and its associated factors among under-five children in Assela referral and teaching hospital, Ethiopia: a hospital based cross-sectional study design

Helen Abebe[1], Berhe Gebremichael[2], Assefa Desalew[4], Melat B. Maruta[3], Addis Eyeberu[4], Jemal Ahmed Nure[4], Adera Debella[4], Lemma Demissie Regassa[2] and Ibsa Mussa[2*]

Abstract

Background Nutritional rickets is a preventable skeletal disorder caused by deficiencies in vitamin D, calcium, or phosphate, leading to softening and weakening of bones. While it was once nearly eliminated in high-income countries, the resurgence of rickets in various parts of the world—particularly in low- and middle-income countries (LMICs)—reflects the ongoing challenges of malnutrition, inadequate healthcare, and socioeconomic factors. This study aimed to determine the prevalence and associated factors of nutritional rickets in the study area.

Methods A hospital-based cross-sectional study was conducted from June 15 to July 30, 2022, involving 442 children under the age of five who visited the pediatric ward, pediatric OPD, EPI, and pediatric emergency departments of referral and teaching hospitals in Assala, Ethiopia. Data were collected using a pre-tested, structured questionnaire administered through face-to-face interviews. A checklist was used for chart reviews. Data were entered into Epidata version 3.1 and analyzed using STATA version 18. Predictors of nutritional rickets were assessed using multivariate logistic regression analysis, with results presented as adjusted odds ratios (AOR) with 95% confidence intervals (CI). A *p*-value of < 0.05 was considered statistically significant.

Results The study found that the prevalence of nutritional rickets in the study area was 3.8% (95% CI: 1.90–5.70). Factors significantly associated with nutritional rickets included being male (AOR = 1.59, 95% CI: 1.10–16.57), lack of information about rickets (AOR = 7.16, 95% CI: 4.22–12.68), and exposure to sunlight while fully dressed (AOR = 3.27, 95% CI: 1.05–5.28).

Conclusions This study indicates that nearly one in every twenty-five children in the study area is affected by nutritional rickets. Factors such as male sex, lack of information about rickets, and inadequate sun exposure due to full clothing were identified as significant risk factors. To prevent this condition, coordinated efforts from all relevant bodies are required. Additionally, raising awareness among mothers and caregivers, particularly through maternal

*Correspondence:
Ibsa Mussa
ibsamussa93@gmail.com

Full list of author information is available at the end of the article

education, is essential. Educated mothers are more likely to adopt improved childcare practices, which can reduce the incidence of nutritional rickets.

Keywords Nutritional rickets, Associated factors, Under-five children, Ethiopia

Introduction

Nutritional rickets is a preventable skeletal disorder caused by deficiencies in vitamin D, calcium, or phosphate, leading to softening and weakening of bones [1]. While it was once nearly eliminated in high-income countries, the resurgence of rickets in various parts of the world articularly in low- and middle-income countries (LMICs) reflects the ongoing challenges of malnutrition, inadequate healthcare, and socioeconomic factors [2]. In these regions, poor dietary diversity, insufficient exposure to sunlight, and limited access to essential nutrients have contributed to the persistence of rickets, especially among young children [3]. The condition disproportionately affects children during critical growth periods, making them particularly vulnerable to lifelong physical impairments if left unaddressed.

Rickets primarily affects children under the age of five, a critical period for bone growth and mineralization. In severe cases, rickets leads to skeletal deformities, delayed growth, and, if untreated, permanent disability or even death [4]. Despite its association with vitamin D and calcium deficiencies, the condition continues to be a significant public health concern worldwide, with sub-Saharan Africa emerging as a focal point for its burden [1]. In Ethiopia, factors such as poverty, inadequate maternal nutrition, limited knowledge, and gaps in healthcare access exacerbate the prevalence of rickets, making it a key challenge for child health programs [2]. This results in the widening and splaying of the growth plates and leads to enlargement of the wrists and costochondral junctions, bowed legs, and knock knees [5].

Assela Referral and Teaching Hospital, located in central Ethiopia, plays a pivotal role in providing healthcare services to the local population, including children who may be at risk for nutritional rickets. Given the importance of early diagnosis and prevention, understanding the prevalence and risk factors associated with rickets in this setting is critical. This study, therefore, aims to assess the prevalence of nutritional rickets among children under five attending the hospital, with a specific focus on factors such as dietary practices, healthcare access, socioeconomic status, and maternal education.

Despite ample sunlight in many tropical regions, including sub-Saharan Africa, nutritional rickets remains a significant public health challenge. In Ethiopia and similar low-resource settings, factors such as poor dietary intake, insufficient sunlight exposure, and inadequate healthcare contribute to the condition's persistence [9]. Even when sunlight is abundant, a lack of vitamin D-rich foods, such as dairy products and fortified cereals, exacerbates the problem. In addition, physiological factors—such as poor calcium absorption—further increase vulnerability, making rickets more difficult to prevent and manage [10].

Nutritional rickets, as a preventable bone disease, arises when essential nutrients like vitamin D, calcium, and phosphate are deficient or improperly utilized, leading to abnormal bone development [3, 6]. In children, the condition manifests in physical deformities such as bowed legs, knock knees, and stunted growth, with the underlying pathophysiology involving impaired mineralization at the growth plates [1, 6]. Children are particularly susceptible to rickets during their first few years of life, a stage marked by rapid growth and an increased demand for vital nutrients.

The complex relationship between vitamin D and calcium complicates rickets' pathophysiology. Vitamin D enhances calcium absorption in the gut, but without sufficient calcium in the diet, children remain susceptible to rickets even if vitamin D levels are adequate [11]. This interdependence between vitamin D and calcium presents significant challenges for effective treatment, particularly in areas where both deficiencies are widespread.

Management of rickets includes correcting calcium deficiencies and increasing dietary intake, which may involve calcium supplements or, in severe cases, intravenous calcium infusions. Governments and healthcare organizations are working to improve access to calcium and vitamin D supplements while raising awareness among healthcare providers and caregivers about early detection and effective management strategies [7, 8].

However, nutritional rickets cannot be solely attributed to dietary deficiencies. A variety of factors, including cultural beliefs, malabsorption issues, and insufficient maternal education, also contribute to its development. As such, addressing rickets requires a holistic approach, incorporating improved dietary practices, health education, and nutritional interventions, with a particular focus on young children and vulnerable populations [7, 9, 10].

Despite significant efforts to combat undernutrition and improve maternal and child health through policies and public health programs, the burden of nutritional rickets in Ethiopia remains poorly understood at the local level. This gap in knowledge, especially regarding the prevalence and determinants of rickets, highlights the need for targeted research and tailored interventions in district like Assela. Therefore, this study seeks to

assess the prevalence of nutritional rickets among children under five in the Assela Teaching and Referral Hospital, identifying key risk factors such as dietary habits, healthcare access, socioeconomic status, and maternal education. By identifying these factors, the study aims to provide actionable insights that can guide public health strategies and contribute to the global effort to reduce the prevalence of this preventable disease.

Ultimately, addressing nutritional rickets in Ethiopia requires a multi-faceted approach. In addition to improving access to essential nutrients and healthcare, it is critical to raise awareness and educate mothers and caregivers about the importance of proper nutrition and sunlight exposure for young children. Despite existing nutrition programs, rickets remains a persistent challenge due to systemic issues in healthcare delivery, nutrition interventions, and caregiver awareness [11, 12]. This research aims to bridge these gaps and provide evidence-based recommendations to help reduce the burden of nutritional rickets in Ethiopia and similar low-income contexts.

Methods and materials

Study design, setting and period

A hospital-based cross-sectional study was conducted from June 15 to July 30, 2022, among 442 children under five years of age who visited the pediatric ward, pediatric OPD, EPI, and pediatric emergency departments of Assela Teaching and Referral Hospital, Ethiopia. The hospital is located in Asela City, Arsi Zone, Oromia Region, Southeast Ethiopia, approximately 175 km east of Addis Ababa. Renovated and restructured as a new facility in 1992, Assela Teaching and Referral Hospital serves a population of 3–4 million in its catchment area, as reported by the zonal health bureaus [13]. The STROBE cross-sectional checklist was used to guide the reporting of this study [14].

Population and eligibility criteria

The source population consisted of all under-five children who visited the pediatric ward, pediatric OPD, EPI, and pediatric emergency departments during the study period. The study population included all under-five children attending these departments. Children were excluded if their mothers or caregivers had a mental health issue or were too ill to respond to questions during data collection.

Data collection methods

Data were collected using a pretested, structured questionnaire adapted from related published literature [7, 15, 16], which was designed to meet the study objectives. The questionnaire included socio-demographic and economic variables (e.g., age, sex, marital status, religion, monthly income, educational status, and occupation). It also included questions on healthcare-related characteristics and child feeding practices.

Data collection was performed by seven BSc-level nurse health professionals who were fluent in Afaan Oromo (the local language). Supervision was conducted by the principal investigator and two public health experts familiar with the study setting. The data collectors and supervisors received four days of training prior to data collection. The questionnaire was first translated into Afaan Oromo, keeping the purpose of the questions intact. To ensure accuracy, the translated version was back-translated into English by a person unfamiliar with the original version. Any discrepancies between the original and back-translated versions were resolved. Additionally, to ensure validity, a set of interviews was conducted in both English and Afaan Oromo, with answers compared to detect any differences in understanding. Cronbach's alpha was used to assess the reliability of the questionnaire, yielding a value of 0.89, which is within the acceptable range.

Anthropometric data collection

Nutritional status was assessed through anthropometric measurements, which included height, weight, and mid-upper arm circumference (MUAC). Weight measurements were taken using a digital scale. For children under two years, weight was measured while the child was lying on a wooden measuring board. For children over two years, a digital scale with an attached height scale was used. The weight scale was calibrated daily, and measurements were taken without heavy clothing, shoes, or bags. MUAC is commonly used to assess the nutritional condition, particularly for identifying undernutrition in children. It is measured using a flexible, non-stretchable tape around the child's left upper arm, at the midpoint between the acromion process and the olecranon. MUAC provides valuable information about muscle mass and fat stores, which can be affected by malnutrition. A low MUAC indicates the presence of acute malnutrition, particularly when used in combination with other anthropometric measures such as weight-for-age and height-for-age z-scores.

Outcome and independent variables

Outcome variable

Nutritional rickets was diagnosed based on the presence of at least three of the following clinical features: bowed legs (genu varum) or knock knees (genu valgum), wrist enlargement, costochondral enlargement (rachitic rosary), delayed motor milestones, and leg pain. Children with a height-for-age z-score < 2 standard deviations (SD) below the WHO median were also screened for inclusion. The diagnostic tool demonstrated a sensitivity of 87%, a

specificity of 76%, a positive predictive value of 73%, and a negative predictive value of 89% in this population [17].

Independent variables

Socio-demographic factors Age, sex, marital status, religion, monthly income, educational status, and occupation.

Healthcare-related factors Healthcare access and utilization.

Child feeding practices Dietary behaviors and patterns related to breastfeeding (e.g., exclusivity, duration, and vitamin D supplementation during breastfeeding) and complementary feeding (e.g., timely introduction of nutrient-dense foods after 6 months of age).

Non-dietary factors Sun exposure practices and health-seeking behavior.

Operational definitions

Caregiver Any person, other than the mother, who provides full-time or partial-time care to the child, such as fathers, siblings, grandparents, or commercial childcare providers.

Chronic illness A persistent disease that an infant or child is suffering from, excluding nutritional rickets.

Diet The foods and drinks that are commonly eaten by the infant or child.

Dietary practices Feeding behaviors, including breastfeeding, complementary feeding, and daily feeding habits.

A fully dressed infant An infant wearing clothing that covers the whole body, except for the face.

Partly undressed An infant dressed in minimal clothing (pants and a vest) where the arms, legs, and face are exposed.

Fully undressed An infant wearing no clothes, except for pants.

Morbidity status The presence of a disease or health condition, other than rickets, affecting the child.

Non-dietary factors include sun exposure practices and health-seeking behavior.

Bias

Some biases were involved in conducting this research, and the researcher took explicit measures to avoid them. One of the biases was social desirability and recall bias. To avoid this, the researcher paraphrased the questions in a way that was not socially desirable and attempted to provide a clue for the intended question that needed to be answered.

Sample size determination and sampling procedures

In this study, the maximum required sample size was calculated using the single population proportion formula by considering the following assumptions:

$$n = ((Z\alpha/2)2(1-p))/d2$$

Where n is the minimum sample size required for the study and Z is the standard normal distribution. Z = 1.96 with a confidence interval of 95% and $\alpha = 0.05$; P = proportion of unmet need for family planning (22%) from a previous study [18]; d = maximum acceptable margin of sampling error (d) = 5% = 0.05; and design effect = 1.5, were 384. After adding contingency (15%) to the non-respondent rate, the minimum sample size for the study was 442.

A multistage sampling technique was used to select participants. Assela Teaching and Referral Hospital was selected purposefully. Four department's pediatric ward, pediatric OPD, EPI, and pediatric emergency were randomly selected using a lottery method. The final sample size was allocated proportionally based on the number of pediatric patients attending each department. The average number of pediatric patients during the previous month was 1,472, with 84 patients in the pediatric ward, 200 in the pediatric OPD, 61 in the EPI, and 97 in the pediatric emergency department. All children who visited the selected departments during the data collection period were included in the study until the required sample size was reached (Fig. 1).

Data quality control

To ensure the quality of the data, the questionnaire was first prepared in English and translated into Afaan Oromo by bilingual experts. A back-translation into English was performed to verify consistency. Data collectors and supervisors received training on the data collection tools and procedures. A pre-test was conducted among 10% of the study participants in a similar setting. Daily checks for completeness and consistency were conducted by supervisors and the principal investigator, with feedback provided to data collectors the following morning. Two data clerks performed double data entry to minimize errors.

Data processing and analysis

Data were first checked for completeness and consistency before being coded and entered into EpiData version 3.1.

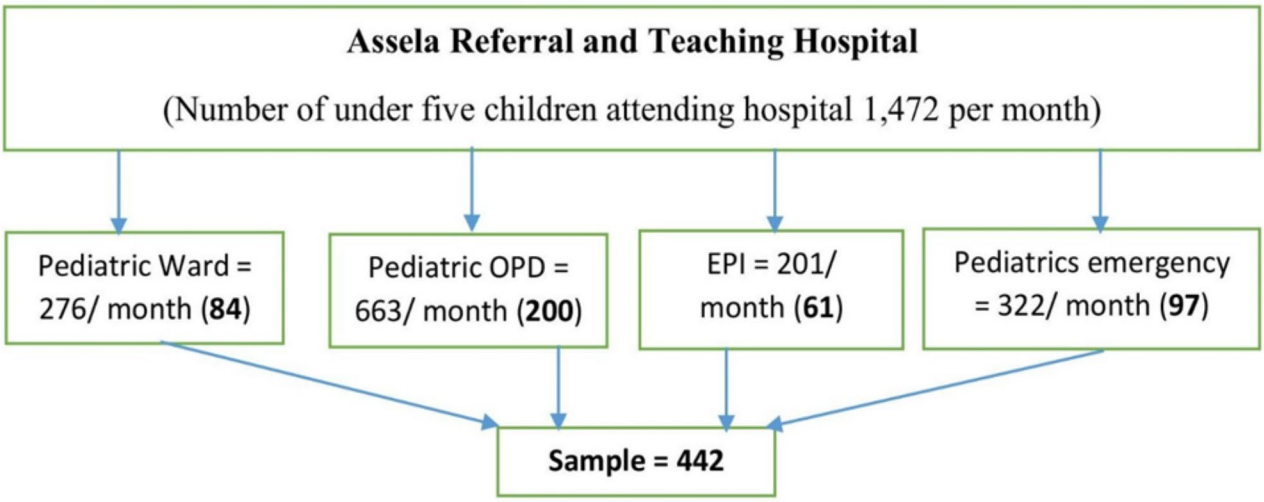

Fig. 1 Sampling technique or procedures of mothers having under five children attending Assela Referral and Teaching Hospital, 2022

The data were then exported to STATA version 18 for further analysis. Descriptive statistics were computed and reported in frequency tables and figures. Binary logistic regression was used to examine associations between variables such as age range (0–59 months), sex, marital status, religion, monthly income, educational status, information availability, occupation, nutritional status, health-related behaviors, feeding behaviors, clinical diagnosis, and nutritional rickets. Model fit was assessed using the Hosmer-Lemeshow test and omnibus tests. Multivariable analysis was performed to identify the factors associated with nutritional rickets, including the child's age range (0–59 months), sex, lack of information, and the way children were dressed during sun exposure. Multicollinearity was checked using variance inflation factor (VIF), which was found to be 0.951, indicating no significant multicollinearity. The direction and strength of associations were measured using odds ratios (OR) and 95% confidence intervals (CI). A p-value of <0.05 was considered statistically significant.

Results

Socio-demographic characteristics of the study participants

A total of 442 children under the age of five, along with their mothers or caregivers, were included in the final analysis, yielding a response rate of 96.0%. Of these, 281 (66.3%) children were male. The mean age of the children was 3 months (±1.2 SD), while the mean age of their mothers/caregivers was 25.52 years (±3.76 SD). Two hundred thirty-seven (55.9%) of the children were from Muslim families. One hundred eighty-seven (44.1%) children were from households with a family size of 5–7 members. One hundred sixty-three (38.4%) of the children belonged to families with an average monthly income ranging from 601 to 1650 Ethiopian Birr (ETB), and 396 (87.0%) of the mothers/caregivers were married. One hundred eighty-six (43.9%) mothers were housewives. Regarding the educational status of the mothers, 177 (41.7%) had received only primary education (Table 1).

Feeding practices and dietary behaviors

More than three-quarters (77.1%) of children were breastfed during the study period. Regarding the frequency of breastfeeding, 128 (30.1%) children were breastfed 8–12 times per day. One hundred and nineteen (28.1%) children started complementary feeding at the age of six months (Table 2).

Frequency of food items consumed

In this study, 300 (83.5%) children consumed milk, 190 (52.9%) consumed cereals, and 130 (36.2%) consumed legumes every day in the last week. Fish/fish oil 10 (2.7%), fruit 36 (10%), meat 55 (15.3%), and eggs 72 (20%) were among the least frequently consumed food groups (Table 3).

Health care related characters

Of the total respondents, 360 (84.9%) attended antenatal care (ANC) follow-ups during their pregnancy with the index child. Of all the mothers, 318 (75.2%) delivered via spontaneous vaginal delivery. Two hundred eighty-eight (67.9%) mothers did not have postnatal care (PNC) follow-up. Approximately 345 (81.4%) of the study sample had no information about nutritional rickets (Table 4).

Non-dietary practices

Out of the 424 children included in this study, 207 (54.4%) were first exposed to sunlight at the age of one

Table 1 Socio-demographic characteristics of mothers/caregivers and their children who visited in Assela teaching and referral hospital, 2022 ($n=424$)

Variable	Categories	Frequency	Percentage
Sex of the child	*Male*	*281*	*66.3*
	Female	*143*	*33.7*
Child age (in completed months)	*0–5*	*46*	*10.8*
	6–11	*111*	*26.2*
	12–23	*113*	*30.4*
	24–35	*91*	*21.5*
	36–47	*63*	*14.9*
Marital status of mothers	*Married*	*396*	*87.0*
	Single	*7*	*1.7*
	Divorced	*47*	*11.1*
	Widowed	*1*	*0.2*
Religion	*Muslim*	*237*	*55.9*
	Orthodox	*143*	*33.7*
	Protestant	*37*	*8.7*
	Others	*7*	*1.7*
Maternal occupation	*Housewife*	*186*	*43.9*
	Unemployed	*35*	*8.3*
	Self employed	*130*	*30.4*
	Governmental employed	*46*	*10.8*
	Farmer	*27*	*6.4*
Family size	*1–4*	*178*	*42*
	5–7	*187*	*44.1*
	8 and above	*59*	*13.9*
Average monthly income in ETB	*Less than 600*	*56*	*13.2*
	601–1650	*163*	*38.4*
	1651–3200	*156*	*36.8*
	3201–5250	*25*	*5.9*
	5251–7800	*16*	*3.8*
	7801–10,900	*8*	*1.9*
Educational status of mothers	*Unable to read and write*	*46*	*10.8*
	Read and write	*77*	*18.2*
	Primary education	*177*	*41.7*
	Secondary education	*91*	*21.5*
	Collage and above	*33*	*7.8*

*1US$ = 57.93 ETB, ETB = Ethiopian birr, others = catholic and Wakefeta

month or older, and 280 (66.0%) were fully dressed during sun exposure. Additionally, 295 (69.6%) of the children were exposed openly to the sky, and 161 (38.0%) were exposed for 10–15 min. The common practice during sun exposure was massaging the child with oil, which was performed on 228 (53.8%) of the children. Three hundred forty-five (81.4%) of the children were fully vaccinated for their age, while 257 (60.6%) had been ill in the last month before the study (Table 5).

Nutritional status of children

Regarding the nutritional status of the children, 214 (50.5%) had a normal height-for-age z-score. However, 153 (36.1%) and 57 (13.4%) children were classified as moderately and severely stunted, respectively. Approximately 153 (36.1%) children had a normal weight-for-age z-score, while 194 (45.8%) and 77 (18.2%) were moderately and severely underweight, respectively. More than one-third (35.4%) of the children had normal weight-for-height, while 152 (35.8%) and 122 (28.8%) were moderately and severely wasted, respectively. Sixteen children (3.8%) were diagnosed with nutritional rickets, representing 3.8% (95% CI: 1.9–5.7) of the study sample (Table 6).

Magnitude of rickets and associated factors

The magnitude of rickets among the under-five children who visited the hospitals was 3.8% (95% CI: 1.90–5.70). In the bivariate logistic regression analysis, the sex of the child, recommended foods for children in the community, IYCF counseling, information about nutritional rickets, common practices during sun exposure, and methods of dressing during sun exposure were included in the multivariate analysis. In the final model, the sex of the child, information about nutritional rickets, and the method of dressing during sun exposure were significantly associated with rickets in under-five children ($P<0.05$).

The odds of male children having nutritional rickets were 1.58 times higher than those of female children (AOR = 1.59, 95% CI: 1.10, 16.57). Children whose mothers had no information about nutritional rickets were 7.1 times more likely to have nutritional rickets compared to those whose mothers had received information about nutritional rickets (AOR = 7.16, 95% CI: 4.22, 12.68). Additionally, children who were exposed to sunlight while fully dressed were 3.2 times more likely to develop nutritional rickets than undressed children (AOR = 3.27, 95% CI: 1.02, 5.28) (Table 7).

Discussions

The prevalence of nutritional rickets in this study was found to be 3.8% in the study area. Several factors were identified as significant predictors of nutritional rickets among children under five, including the sex of the child, lack of information about nutritional rickets, and the way children were dressed during sun exposure.

The prevalence of nutritional rickets in this study aligns, which aligns with institution-based studies in Kenya (3.4%), and Saudi Arabia (3.5%) [19]. However, the prevalence in this study is notably lower compared to population-based studies in Ethiopia (10.5%) [20], Turkey (6%) [21], Norway (15%) [22], Qatar (23.9%) [23], Eastern Ethiopia (7.8%) [20], Bangladeshi (10.6%) [24], and Kenya (28%) [25]. These discrepancies may reflect methodological differences, such as study design (institution- vs. population-based) and diagnostic criteria. Specifically, socio-demographic factors in the current study setting, such as the low educational and socioeconomic status of

Table 2 Child feeding practices among mothers/caregivers of under-five children who visited in Assela teaching and referral hospital, 2022

Variables	Categories	Frequency	Percentage
Frequency of breastfeeding (*n* = 327)	Per need	52	12.3
	Less than 8 times	64	15.1
	8–12 times	128	30.2
	12 and above times	83	19.6
Duration of feeding (*n* = 307)	Never	25	5.9
	6 months	37	8.7
	1 year	94	22.2
	2 and above	151	35.6
First food given (*n* = 392)	Breast milk	251	55.2
	Water	86	20.3
	Other food*	55	13.0
Times of initiation for complementary (*n* = 316)	Before 6 months	123	29
	At 6 months	119	28.1
	After 6 months	74	17.5
Special foods recommended for children in the community	Yes**	126	29.7
	No	298	70.3
Special foods restricted for children in the community	Yes***	15	3.5
	No	409	96.5

*Butter, formula milk, honey, porridge, and fruits (juice); ** Milk, porridge and potato; *** uncooked/raw foods, meat, fish and egg

Table 3 Frequency of food items consumed among mothers/caregivers of under-five children who visited in Assela teaching and referral hospital, 2022

Variable	< one week	1–2 times a week	3–6 times a week	Never	Daily
Cereals	20(5.5%)	13(3.6%)	94(26.1%)	42(11.6%)	190(52.9%)
Fruits	0(8.3%)	80(22.2%)	43(11.9%)	170(47.3%)	36(10.0%)
Vegetable	90(25.0%)	45(12.5%)	61(16.9%)	100(27.8%)	63(17.5%)
Eggs	89(24.7%)	23(6.4%)	70(19.4%)	105(29.3%)	72(20.0%)
Fish/fish oil	43(11.9%)	9(2.5%)	7(1.9%)	290(80.7%)	10(2.7%)
Meat	78(21.7%)	17(4.7%)	20(5.5%)	189(52.6%)	55(15.3%)
Milk	28(7.7%)	4(1.1%)	7(1.9%)	17(4.9%)	300(83.5%)
Legumes	15(4.1%)	14(3.8%)	150(41.7%)	50(13.9%)	130(36.2%)

Table 4 Health care service use characteristics of among under-five children who visited Assela teaching and referral hospital, 2022

Variable	Categories	Frequency	Percentage
ANC follow up	*Yes*	*360*	*84.9*
	No	*64*	*15.1*
Mode of delivery	*Spontaneous vaginal delivery*	*318*	*75.2*
	Cesarean section	*49*	*11.6*
	Instrumental delivery	*57*	*13.4*
Type of pregnancy	*Singleton*	*417*	*98.3*
	Twins	*7*	*1.7*
PNC follow up (424)	*Yes*	*136*	*32.1*
	No	*288*	*67.9*
IYCF counseling during ANC Follow up (424)	*yes*	*78*	*18.4*
	No	*346*	*81.6*
Information about rickets (424)	*Yes*	*79*	*18.6*
	No	*345*	*81.4*

participants, might have contributed to the lower prevalence. Furthermore, the sample size of the study population could have influenced the results. Additionally, the fact that our study was institution-based, using data from selected health facilities, contrasts with the population-based design of the other studies, which may also explain the observed differences.

In the final multivariable analysis model, sex was found to be a significant predictor of nutritional rickets. The odds of developing rickets were 1.5 times higher in male children compared to female children. This finding is consistent with studies conducted in Yemen [21, 26]. This disparity may arise from biological and sociocultural mechanisms. Male infants are physiologically less mature at birth, increasing susceptibility to nutrient deficiencies [27, 28]. Furthermore, cultural practices in some Ethiopian communities prioritize male children for outdoor labor, inadvertently increasing sunlight exposure, but paradoxically, this may not offset dietary calcium or vitamin D deficits [17]. Conversely, in regions where girls

Table 5 Non-dietary practices towards the prevention of rickets among under-five children who visited Assela teaching and referral hospital, 2022

Variables	Categories	Frequency	Percentage
Age at first sun exposure (395)	First week	13	3.3
	Second week	107	27.1
	Third week	68	17.2
	After 1 month	207	54.4
Dressing during sun exposure	fully dressing	280	66.0
	Undressed	144	34.0
Way of sun exposure	Open to the sky	295	69.6
	Under shade	81	19.1
	Inside home	48	11.3
Duration of sun exposure in minute	< 4–10 min	87	20.5
	10–15 min	161	38.0
	15–20 min	133	31.4
	> 20 min	42	10.1
Practice during sun exposure	No oil massage	196	46.2
	Oil massage	228	53.8
Child vaccinated for his/her age	Yes	345	81.4
	No	79	18.6
Child sickness within one month	yes	257	60.6
	No	167	39.4

Table 6 Nutritional rickets and nutritional status of children among under-five children who visited Assela teaching and referral hospital, 2022

Nutritional indices	Nutritional status	Frequency	Percentage
Height for age (z-score)	Normal (≥-2)	214	50.5
	Moderate stunting(-3 to <-2)	153	36.1
	Severe stunting (<-3)	57	13.4
Weight for age(z-score)	Normal(>-2)	153	36.1
	Moderate underweight(-3 to <-2)	194	45.8
	Severe underweight(<-3)	77	18.2
Weight for height(z-score)	Normal(≥-2)	150	35.4
	Moderate wasting(-3 to <-2)	152	35.8
	Sever wasting(<-3)	122	28.8

are preferentially breastfed longer or given calcium-rich foods, their lower rickets risk may reflect gendered feeding practices [17].

This study also found that a lack of information about nutritional rickets among mothers was an independent predictor of nutritional rickets in their children. The odds of nutritional rickets were 7.15 times higher among mothers who were unaware of nutritional rickets compared to those who had information about the condition. This finding is in line with previous research conducted in Ethiopia [20, 29]. One plausible explanation for this is that mothers with knowledge of nutritional rickets are more likely to apply preventive measures effectively. Many mothers without this information may not have had access to media campaigns or educational programs that promote awareness about the importance of sunlight exposure for their children's health.

Additionally, this study confirmed that the way children were dressed during sun exposure was positively associated with the development of nutritional rickets. Specifically, the odds of developing rickets were 3.27 times higher among mothers who dressed their children fully while exposing them to the sun. This finding is consistent with studies conducted in other settings [20, 23, 29]. A possible explanation for this could be that clothing hinders the child's full exposure to sunlight, which is necessary for the production of vitamin D, thereby increasing the risk of rickets. Cultural practices and religious beliefs that dictate how children are dressed, especially concerning sun exposure, may also play a role in this gender disparity. In many regions, girls are more likely to be fully covered due to religious or cultural norms, limiting their exposure to sunlight and increasing the risk of rickets. This could be particularly important in areas where sunlight is essential for the synthesis of vitamin D, and the practice of full clothing may exacerbate the prevalence of the condition in females.

Limitation of the study

Despite the valuable findings of this study, there are several limitations that should be considered when interpreting the results:

Cross-sectional design The study's cross-sectional design limits the ability to establish causal relationships. While associations between risk factors and nutritional rickets were identified, the temporal sequence of events cannot be conclusively determined. This means that while factors like male sex, lack of awareness, and full clothing during sun exposure are linked to nutritional rickets, it is not possible to definitively infer cause and effect.

Recall bias Data collection was based on face-to-face interviews with caregivers using structured questionnaires, which may be subject to recall bias. Caregivers might not accurately remember or report practices related to nutrition, sunlight exposure, or other relevant factors, leading to potential misclassification of exposures.

Sample size and generalizability Although the study included 442 children, the sample was limited to children attending pediatric outpatient and inpatient departments in Assela, Ethiopia. This may not fully represent the broader population of children under five in the region, as those who do not visit hospitals may differ in their expo-

Table 7 Magnitude of rickets and associated factors among under-five children who visited Assela teaching and referral hospital, 2022

Variable	Category	Rickets		COR(95% CI)	AOR (95% CI)
		Yes (%)	No (%)		
Sex of child	Male	8(2.8%)	273(97.2%)	0.495(0.082,1.346)	1.586(1.095,16.568)*
	Female	8(10.6%)	135(94.4%)	1	1
Recommended foods for children in the community	Yes	7(43.8%)	119(29.2%)	1.889(0.688,5.189)	1.258(0.404,5.351)
	No	9(31.3%)	289(70.8%)	1	1
IYCF counseling	Yes	7(43.8%)	241(97.2%)	1	1
	No	9(56.3%)	167(94.9%)	1.855(0.678,5.080)	2.038(0.286,14.553)
Information about rickets	Yes	11(69.8%)	334(81.9%)	1	1
	No	5(33.3%)	74(18.1)	2.052(0.692,6.082)	7.158(4.217,12.683)*
Common practice during sun exposure	No oil massage Oil massage	10(62.5%)	186(45.6%)	0.502(0.198,1.468)	0.152(0.023, 0.994)
		6(37.5%)	222(54.4%)	1	1
Way of dressing during sun exposure	Well dressed	8(50.0%)	272(66.7%)	0.5(0.184,1.361)	3.270(1.016, 5.28) *
	Un dressed	8(50.0%)	136(33.3%)	1	1

*Significant at $p < 0.05$

sure to risk factors for rickets. Therefore, the findings may not be generalizable to other regions or countries, particularly those with different healthcare access or socioeconomic conditions.

Lack of information on dietary intake While the study identified sunlight exposure and awareness as significant factors, it did not comprehensively assess the dietary intake of calcium and vitamin D. Since nutritional rickets is primarily caused by deficiencies in these nutrients, future studies should include detailed dietary assessments to better understand their role in the condition.

Potential confounding variables Although multivariate logistic regression was used to control for potential confounders, there may still be unmeasured factors influencing the occurrence of rickets. For instance, socioeconomic status, maternal health, or other environmental factors such as air pollution (which may reduce sunlight exposure) were not thoroughly explored in this study and could influence the outcomes.

Regional focus The study focused on Assela, which may limit the applicability of its findings to other parts of Ethiopia or countries with different environmental and healthcare contexts. Factors such as seasonal variation in sunlight exposure, cultural practices, and local health interventions could vary significantly from region to region, affecting the prevalence and risk factors for nutritional rickets.

Single-location study The study was conducted in referral and teaching hospitals in Assela. As these institutions typically serve a population that may have higher rates of illness or healthcare-seeking behavior, the study sample might not represent the general population of children under five in the area.

Suggestions for future research

Longitudinal studies To establish causal relationships between risk factors and nutritional rickets, longitudinal studies should be conducted that track children over time to observe how variations in sunlight exposure, dietary habits, and awareness affect the development of rickets.

Larger, multi-center studies Expanding the study to include multiple centers across different regions of Ethiopia, and potentially neighboring countries, would provide a more comprehensive understanding of the prevalence and risk factors for nutritional rickets in diverse settings.

Dietary assessments Future studies should incorporate more detailed information on children's dietary intake, particularly focusing on the intake of calcium, vitamin D, and other micronutrients essential for bone health. This would help clarify the role of nutrition in preventing rickets.

Intervention studies To assess the effectiveness of educational and intervention programs, randomized controlled trials (RCTs) could be implemented to determine the impact of raising awareness among caregivers, particularly mothers, on reducing the incidence of nutritional rickets.

Conclusions

This study highlights the urgent need to address the prevalence of nutritional rickets among children in Assela, Ethiopia, with a focus on gender-sensitive interventions. Key factors such as male sex, lack of awareness about rickets, and inadequate sun exposure due to full clothing were identified as significant risk factors. Moving forward, comprehensive strategies including food fortification policies, community-based education programs, and targeted health interventions that consider both nutritional and non-nutritional factors

are essential for reducing the burden of rickets. Furthermore, addressing gender disparities and promoting equal access to healthcare and nutritional resources will be vital for mitigating the prevalence of rickets in both sexes.

Recommendation

Gender-sensitive interventions Future interventions should specifically address gender-related barriers, such as culturally determined clothing practices that limit sunlight exposure for female children.

Maternal education Investing in maternal education to raise awareness about vitamin D, calcium, and the prevention of rickets can have a long-lasting impact on reducing its incidence.

Policy integration Health and nutrition policies should be integrated, particularly focusing on vitamin D fortification and sun exposure guidelines as part of national child health programs.

Public awareness campaigns Public health campaigns should emphasize the importance of sunlight exposure and dietary diversification, including the consumption of fortified foods, for preventing nutritional deficiencies that lead to rickets.

Abbreviations

25(OH)	D 25 hydroxyvitamin D
ALP	Alkaline phosphatase
ALRI	Acute lower respiratory tract infection
AOR	Adjusted Odds Ratio
CI	Confidence Interval
COR	Crude Odds Ratio
OPD	Outpatient Department
MUAC	Mid-Upper Arm Circumference
WHO	World Health Organization

Acknowledgements

The authors would like to thank Haramaya University College of Health and Medical Science for its cooperation in providing the study. The authors would also like to express their gratitude to study participants in the region for their genuine cooperation during the data collection and throughout the study.

Author contributions

HA and IM conceived and designed the study HA, GB, and IM drafted the manuscript, and HA was the PI of the review. HA, GB, AD, and IM developed search strings. Both reviewers (HA, GB, AD, MB, AE, JAN, AD, LDR, IM) screened and selected studies. HA and IM evaluated the quality of the studies. HA, GB, AD, and IM performed analyses and interpretations. Both authors have rigorously reviewed, read, and approved the final version of the manuscript.

Funding

No funding.

Data availability

All data generated and analyzed during this study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the Institutional Health Research Ethics Review Committee (IHRERC) of Haramaya University, College of Health Sciences. Support letters from the College of Health Sciences were submitted to the selected kebeles where the study was conducted. After getting all permission letters from the responsible body and being informed, voluntarily, written informed consent was signed by study participants. Confidentiality was maintained by using codes instead of the participant's name. Participants were also informed that they had the full right to refuse participation or withdraw at any time from the research. All methods were performed following relevant guidelines and regulations in the Declaration of Helsinki.

Consent for publication

Consent for publication for this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare no competing interests.

Author details

[1]School of Public Health, College of Health and Medical Sciences, Arsi University, Asella, Ethiopia
[2]School of Public Health, College of Health and Medical Sciences, Haramaya University, Harar, Ethiopia
[3]Obstetrics and Gynecology, Menelik Hospital, Addis Abeba, Ethiopia
[4]School of Nursing and Midwifery, College of Health and Medical Sciences, Haramaya University, Harar, Ethiopia

Received: 25 August 2023 / Accepted: 4 April 2025
Published online: 17 April 2025

References

1. Chanchlani R et al. An overview of rickets in children. 2020. 5(7): pp. 980–90.
2. Robert M, Kliegman JWSGI. Nelson textbook of pediatrics. 2-Volume Set. 2020. 2(21st).
3. Cesur Y et al. Evaluation of children with nutritional rickets. 2011. 24(1–2): pp. 35–43.
4. Lambert A et al. Hypocalcaemic and hypophosphatemic rickets. 2018. 32(4): pp. 455–76.
5. Al-Atawi MS et al. Epidemiology of nutritional rickets in children. Saudi J Kidney Dis Transplantation, 2009. 20(2).
6. Lambert AS, Linglart A. Hypocalcaemic and hypophosphatemic rickets. Best Pract Res Clin Endocrinol Metab. 2018;32(4):455–76.
7. Uday S, Högler W. Nutritional rickets & osteomalacia: A practical approach to management. Indian J Med Res, 2020. 152(4).
8. Haffner D, et al. Rickets guidance: part II—management. Pediatr Nephrol. 2022;37(10):2289–302.
9. Pettifor JM. Nutritional rickets: deficiency of vitamin D, calcium, or both?23. Am J Clin Nutr. 2004;80(6):S1725–9.
10. Munns CF, et al. Global consensus recommendations on prevention and management of nutritional rickets. J Clin Endocrinol Metabolism. 2016;101(2):394–415.
11. Endris BS, et al. Barriers and facilitators to the implementation of nutrition interventions at primary health care units of Ethiopia: A consolidated framework for implementation research. Matern Child Nutr. 2023;19(1):e13433.
12. Ahmed KY, et al. Interventions to improve the nutritional status of children under 5 years in Ethiopia: a systematic review. Public Health Nutr. 2023;26(12):3147–61.
13. AZHO. Reported by zonal health bureaus. Arsi Zonal Health Office; 2022.
14. Elm Ev, et al. Strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. BMJ. 2007;335(7624):806.
15. Darraj H, et al. Nutritional rickets among children: A retrospective study from Saudi Arabia. Pediatr Health Med Ther. 2023;14(null):301–8.

16. Kjerulff KH, et al. Mode of first delivery and women's intentions for subsequent childbearing: findings from the first baby study. Paediatr Perinat Epidemiol. 2013;27(1):62–71.
17. Fischer PR, et al. Nutritional rickets without vitamin D deficiency in Bangladesh. J Trop Pediatr. 1999;45(5):291–3.
18. EDHS. Ethiopia demograph Health suervey and surviliance. 2016.
19. Mwirigi FM. and F.S. Theuri. The challenge of value addition in the seafood value chain along the Kenyan north coast. 2012.
20. Chala Kenenisa HE, Sime H. Retrospective analysis of prevalence of rickets and associated factors among children admitted to pediatric ward in Jimma university specialized hospital. 2014(7).
21. Hátún H, et al. Influence of the Atlantic subpolar Gyre on the thermohaline circulation. Science. 2005;309(5742):1841–4.
22. Meyer HE, et al. Nutritional rickets in Norway: a nationwide register-based cohort study. BMJ Open. 2017;7(5):e015289.
23. Bener A, Hoffmann GF. Nutritional rickets among children in a sun rich country. Int J Pediatr Endocrinol. 2010;2010(1):410502.
24. Ahmed S, et al. Aetiology of nutritional rickets in rural Bangladeshi children. Bone. 2020;136:115357.
25. Edwards JK, et al. Preventable but neglected: rickets in an informal settlement. Nairobi Kenya Public Health Action. 2014;4(2):122–7.
26. Mwirigi FM, Theuri FS. The challenge of value addition in the seafood value chain along the Kenyan North Coast 51. 2012.
27. Hutt C. Sex differences in human development. Hum Dev. 2009;15(3):153–70.
28. Thurstans S, et al. Understanding sex differences in childhood undernutrition: A narrative review. Nutrients. 2022;14. https://doi.org/10.3390/nu14050948.
29. Mohanna MB. Prevalence of nutritional rickets among symptomatic children and associated risk factors in specialised Sam paediatric centre Yemen. East Afr Med J. 2015;92:600–4.

Publisher's note