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**UNDER-FIVES RICKETS IN A TROPICAL DAIRY FARMING REGION, KIAMBU COUNTY,
KENYA**

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Abstract

The objective of this study was to determine under-fives feeding patterns on calcium and vitamin D rich foods as well as care practices in relation to rickets in an area dominated by dairy farming and sunlight, Kiambu County, Kenya. An unmatched case-control study design was used. The case group comprised of 200 children with rickets while the comparison group were a similar number of children without rickets. Study participants were selected during their visit to Kiambu Level Four Hospital. Data collection was performed using a pretested questionnaire. Dietary calcium, phosphorus and vitamin D intake were determined by single 24 hour dietary recall method and nutrient intakes computed using NutriSurvey software. Inadequate intake of calcium and vitamin D rich foods was observed. The mean (\pm standard deviation) intake of calcium and vitamin D was 190.7 ± 114.1 mg/day and 0.02 ± 0.05 μ g/day, respectively, all below Recommended Daily Allowances. Significant risk factors towards rickets detected were consumption of breakfast cereals (Odds ratio (OR) 3.8) and porridge made with multiple cereal/legume composite flours (OR 6.7). Protective factors were daily child exposure to sunlight (OR 0.035), consumption of meat (OR 0.34) and living in open residential houses (OR 0.42). Therefore, by simply sunbathing and feeding children with cereal gruels of high bio-available micronutrients, addition of meat in child's diet and supplementation with cod liver oil are effective ways of eradicating rickets in low income economies. Policy makers should explore under-fives supplementation with vitamin D and fortification of baby breakfast cereals with calcium.

Key words: Rickets, Vitamin D supplementation, Dietary Calcium, Sun bathing

Introduction

Rickets remains a major public health problem in many developing countries where it seems to be re-emerging (Welch et al. 2000; Allgrove 2004; Bereket 2010; Melamed & Kumar 2010). Overall, one billion people in the world have rickets and majority of the affected are children suffering from severe malnutrition associated with famine or starvation during the early stages of childhood (Taylor 2008). Although cases of rickets have declined since

industrial revolution, certain populations remain at risk especially children in developing world. In recent years, global public health and nutrition interventions are focused primarily on over- and under-nutrition and associated conditions but there is minimal focus on rickets, but, vitamin D deficiency could be an under recognized global mother-infant health problem (Dawodu & Tsang 2012).

The long-term vitamin D deficiency in children leads to rickets with significant skeletal deformities and poor growth (Dawodu & Tsang 2012). The main source of vitamin D for breastfed infants and newborns is placental transfers, breast milk and sunlight exposure (Hollis & Wagner 2004). However, breast milk contains relatively low quantity of vitamin D particularly 25-Hydroxyvitamin to prevent vitamin D deficiency in exclusively breast-fed infants if sunlight exposure is limited (Ala-Houhala et al. 1988; Pugliese et al. 1998; Thacher et al. 1999; Kreiter et al. 2000; Aggarwal et al. 2012). This is because vitamin D stores in infants at birth depends on maternal vitamin D status during pregnancy (Hollis & Wagner 2004). Vitamin D is a hormone that aids in calcification of bones and teeth (Bouillon 2010; Bouillon 2017). Since calcium is also obtained from milk, the prevention of rickets by consumption of dairy products in a region prominent in dairy farming is not clear. On the other hand, vitamin D is naturally synthesized under the skin of mammals exposed to ultra-violet light or sunshine (Aggarwal et al. 2012) and at the same time, rickets is still a problem in sun rich tropical countries (Bouillon 2010). Therefore, this study was conducted to determine factors associated with rickets among under-fives in the Central region of Kenya, as a starting point.

Methods

Study setting

The study was conducted in Kiambu Level Four Hospital, located in Kiambu County, Kenya. The county covers an area of 1,323.9 Km² and lies between latitudes 0° 75' and 1° 20' South of Equator, and longitudes 36° 54' and 36° 85' East (NCPAD 2011). It borders Nairobi City and Kajiado County to the South, Nakuru County to the West and Nyandarua County to the Northwest (NCPAD 2011).

Study Design and participants

An unmatched case-control study design was used. Two hundred (200) children aged 6-59 months with rickets were selected exhaustively at Kiambu Level Four Hospital when attending the facility for health care services at Out-patient Department, Paediatric ward and Physiotherapy Division of the Hospital. To form the comparison group, a similar number of

children without rickets were randomly selected by choosing every second child following selection of a child with rickets. The sample size calculation was based on the Fleiss formula (Fleiss 1981) for case-control studies, assuming a statistical power of 80 % and a ratio of 1:1 for cases and controls. The study was conducted during the months of August and September 2011.

Data collection

A pretested structured questionnaire was used to collect data. The respondents were mothers or caregivers of selected children. The dependent variables measured were breast feeding practices, complementary feeding practices, type of houses occupied, sunbathing practices and morbidity experience of the children. Presence of rickets was determined by physical examination by trained nurse deployed at Kiambu Level Four hospital. Co-morbidities were determined through self-reporting by respondents. A single 24 hour recall questionnaire was administered to determine dietary intake of vitamin D, calcium and phosphorus. Measurement of food weights and/or the volume equivalent of foods was performed using kitchen food scale. The volume equivalent weight of household food measures used to estimate quantity of foods was in this manner converted to metric units - grams or milligrams. The weighing scales were calibrated regularly to ensure accurate readings.

Interviews for filling the questionnaires were conducted by research assistants who had been trained on best practices and ethical issues. The research assistants also performed supervised piloting of study protocols in Nguriunditu Village, Kikuyu Division. In addition, to ensure quality of collected data, filled questionnaires were reviewed on daily basis and problems encountered rectified. This study was approved by Kiambu Level Four Hospital before start of data collection. Informed consent was obtained from the caregivers of study participants without any coercion.

Statistical data analysis

Computations of daily nutrient intake from 24 hour dietary recall data were performed using Nutrisurvey software (2007). The nutrient intake data and all other data were entered to a database of Statistical Package for Social Sciences (SPSS) software version 16. Data cleaning and statistical analysis were performed using SPSS. Means and standard deviation of vitamin D, calcium and phosphorus daily intakes were computed using descriptive statistics and Chi square test and uni-variate logistic regression analysis. The level of significance was set at 95 %.

Results

Contextual characteristics of study participants

The age category of 6-12 months had the largest number (58.5 %) of children suffering from rickets (Table 1). About 28.6 % of the children with rickets had not been exclusively breastfed for six months compared to 4.8 % of children without rickets (Table 1). Thirty one percent (31 %) of the children with rickets stopped breastfeeding at the age of 7-12 months while only 11 % of the children without rickets stopped being breastfed at this time (p-value <0.001) meaning breastfeeding was stopped earlier for more children with rickets. Similar trend was also observed for the initiation of complementary feeding where 74 % of children without rickets were introduced to complementary foods after 6 months of age compared to 46.5 % of the case group. About 3 % of the case group were introduced to complementary feeds at the age of 1 month, and 8.5 % at the age of two months, which is quite early to initiate other foods to infants.

Table 1: Feeding and child care practices of children with and without rickets in Kiambu County, Kenya

Characteristics	Children with rickets (n=200) Percent	Children without rickets (n=200) Percent
Gender of the study children		
Male	58	53.5
Female	42	46.5
Age category of children (Months)		
6-12	58.5	43.5
13-19	26.5	29.5
20-26	12	10
27-33	2.5	5.5
>34	0.5	11.5
Breast feeding status		
Yes	73	85
No	27	15
Duration of breast feeding		
0-6 months	28.6	4.8
7-12 months	31.4	11.1
13-18 months	20	30.2
19+ months	20	54
Age of complementary feeding (Months)		
1	3	1
2	8.5	1.5
3	11	5
4	13.5	4
5	15.5	15
6	46.5	73.5
Type of house		
Bungalow	70.5	84

Flats	29.5	16
Care givers of the study children		
Mother	78.5	86.5
Alternative care givers	21.5	13.5
Sunbathing		
Sunbathing	63	98.5
No sun bathing	37	1.5
Child welfare clinic visits		
Yes	62.5	74
No	32.5	26

Close to thirty percent (29.5 %) of children with rickets lived in multi-storey residences (flats) compared to 16 % of children without rickets who resided in the same residential premises (p-value < 0.01) (Table 1). Mothers were the principal caregivers for the case group (78.5%) compared to 86.5 % for the comparison group (p-value <0.05), indicating that children raised by mothers were less likely to develop rickets compared to the ones raised by other caregivers. Sunbathing was more common (98.5 %) among the children without rickets compared to 63 % of children with rickets (p-value<0.05). The proportion of cases (63 %) taken to child welfare clinics was statistically lower than controls (74%) meaning children were less likely to get rickets if they routinely attended well-baby clinics. The mean daily dietary intake of calcium was 191±114.1 mg (Mean, SD) for children with rickets and 264±114.1 mg for children without rickets (p-value=0.002). Similar trend was observed for mean daily dietary intake of phosphorus (Table 2). The mean dietary intake of vitamin D among the study groups was not statistically significant ranging between 0.2-0.3 µg/day.

Table 2: Mean daily dietary intake of calcium, phosphorus and vitamin D among children aged 6-59 months in Kiambu County

Food nutrient	Children with rickets (n=51)		Children with rickets (n=49)		p value
	Mean±SD	95% CI	Mean±SD	95% CI	
Calcium	190.7±114.1	158.6- 222.8	264±114.1	232.1-297.6	*0.002
Phosphorus	227.6±137	189.1 - 266.2	332.1±124.8	296.3-367.9	*0.000
Vitamin D	0.02±0.05	0.0004-0.03	0.03±0.09	0.0005-0.06	0.415

*Significant at p<0.01; n was lower than the sample size of 200 for each group because a sub-sample was interviewed on the 24 hour dietary recall

The frequencies of consumption of vitamin D and calcium-rich foods are presented in Table 3. There was a significant difference in the frequency of consumption of meat, liver, cabbages, and eggs between the two groups. Fish was rarely consumed by children from the two groups. Majority of the children suffering from rickets were fed on spinach and breakfast cereal and composite cereal flours.

Table 3: Frequency of consumption of Calcium and vitamin D foods among children with and those without rickets in Kiambu County

Type of food	Children with rickets		Children without rickets		χ^2	p-value
	consumed	Never consumed	consumed	Never consumed		
Milk	88	12	93.5	6.5	3.60	0.058
Yogurt	22	78	32.5	67.5	5.56	*0.018
Meat	17	83	37	63	20.29	**0.000
Peas	12.5	87.5	14.5	85.5	0.343	0.558
Liver	17	83	31	69	10.75	**0.001
Fish	27.5	72.5	34	66	1.98	0.159
Tomatoes	84.5	15.5	80.5	19.5	1.108	0.292
Bread	30.5	69.5	39.5	60.5	3.560	0.059
Kales	25.5	74.5	29	71	0.618	0.432
Spinach	87	13	75.5	24.5	8.68	**0.003
Eggs	39	61	49	51	4.06	*0.044
Bananas	79	21	76	24	0.516	0.472
Beans	65	35	73.5	26.5	3.39	0.065
^a Cereal mixtures	93	7	66.5	33.5	43.4	**0.000
Breakfast cereal	68	32	41	59	29.4	**0.000

^aCereal mixtures is porridge prepared with multiple cereals or a mixture of 2-3 different cereal flours; n= 200 for case- and n=200 for control- groups; * Significant at p<0.05; ** Highly significant (p<0.01)

Children's co-morbidities

Children suffering from rickets were more prone to diseases such as respiratory infections (63 %) compared to 26 % of children without rickets (Table 4). Diarrhoea and vomiting were also important co-morbidities for children with rickets. The co-morbidity status between the two groups was highly significant (p<0.01).

Table 4: Prevalence of co-morbidities for the study groups

Disease	With rickets Frequency (%)	Children without rickets Frequency (%)
Lower respiratory tract infections	63	26.5
Diarrhea and vomiting	10.5	12.5
Infections	4.5	3
Malaria	1.5	0.5
Malnutrition	0.5	2
Chicken pox	1.5	2
Measles	1	1

n= 200 for case group and n=200 for control group

Determination of the factors associated with rickets in Kiambu County

Univariate logistic regression analysis (Table 5) identified the following protective factors against rickets; exclusive breast feeding of children (OR 0.4), feeding children with meat (OR 0.3), living in bungalows or open houses (OR 0.4), and daily sunbathing of children (OR 0.03). Feeding children with liver and frequent visit to child welfare clinics are potential

protective factors, although, the level of significance was not reached. However, feeding children on breakfast cereals (OR 3.8) or porridge prepared using multiple cereal/legume flours (OR 6.7) were identified as risk factors of under-fives rickets. Intake of spinach (OR 1.9, P-value= 0.06) was borderline significantly associated with rickets in under-fives.

Tale 5: Univariate logistic regression of feeding and child care practices on children with and without rickets in Kiambu County

Explanatory variables	Std. Error	p-value	Odds Ratio
Intercept	0.838	0.000**	
Exclusive breastfeeding	0.269	0.000**	0.390
Meat intake	0.328	0.001**	0.340
Liver intake	0.323	0.392	0.758
Spinach intake	0.337	0.055*	1.906
Breakfast cereal intake	0.271	0.000**	3.876
Porridge of multiple flour mix with/out milk	0.42	0.000**	6.693
Live in a Bungalow	0.310	0.005**	0.420
Sunbathing daily	0.625	0.000**	0.035
Visits Child Welfare Clinics	0.292	0.074	0.593
Mother of child is care giver	0.365	0.891	1.051

*P-value=borderline 0.05 ** Highly significant P-value <0.01.

Discussion

The current study shows that male children were slightly more than female children, with a ratio of 1.2 : 1, a proportion that was similar to a study carried out at Kenyatta National Hospital to assess the prevalence of rickets (Kinuthia et al. 1994). Furthermore, children who were less than one year of age were more susceptible to rickets than older children concurring with a study conducted at Lady Reading Hospital in Peshawar, Jordan, where 66% of the children were less than one year of age (Khan et al. 2001).

Although, exclusive breastfeeding is not universally practiced by mothers of study participants, a higher prevalence of exclusive breastfeeding was observed in the study area than the national prevalence of 32 % (UNICEF 2006). At the national level, correlation of exclusive breastfeeding with rickets has not been performed. World Health organization (WHO) 2011), recommends exclusive breastfeeding for the first 6 months after birth. After this period, complementary feeding should start while continuing with breast feeding until the child is 24 months. This study, showed early introduction to complementary foods was a risk factor for development of childhood rickets, also linked to poor nutritional value of complementary foods (Majeed et al. 2007).

The frequency of consumption of animal source foods rich in calcium and phosphorus such as eggs, meat and liver were higher in the children without rickets compared to the children who had rickets. Since, eggs contain 220 mg of phosphorus per 100g, meat contains 170 mg per 100 g while liver has 400 mg per 100g (Schlenker 2011), the low intake of these foods likely explains why the case group was predisposed to rickets (Aggarwal et al. 2012). On the other hand, green leafy vegetables such as spinach contain high calcium content but also have anti-nutrients such as oxalic acid and phytates which compromise bio-availability of calcium (Joshi 2010). According to Andrew (Andrew 1976), a 125g cup of cooked spinach contains 750 mg of oxalates compared to 125 mg in kales which indicates the almost significant association as potential risk. The Food and Nutrition Board recommends 270-500 mg per day of calcium, which is much higher than the intakes observed in this study. The mean calcium intake for the case group was 190 (SD 114.1) mg per day and 264 (SD 114.1) mg per day for control group. The low dietary intake of calcium and phosphorous is an important factor in the occurrence of rickets. Phosphorus is abundant in foods, but still, majority of study participants did not meet levels of adequate intake.

The daily consumption of foods rich in vitamin D in the current study was also below the recommended intake of 5 µg per day (Holick et al. 1992). A good source of vitamin D is fish; however, fish is not a staple food in Central Province where the study was conducted. This was further complicated by the fact that most caregivers did not take their children for sunbathing. On the other hand, the nature of housing for the majority of children with rickets was multiple storey buildings commonly referred to as flats, which also prevented synthesis of vitamin D due to less exposure of children to sun rays. Similar findings were reported in Pakistan where majority of children with rickets lived in flats while a very small percent lived in open houses (Khan et al. 2001). Inadequate exposure to sunlight might be associated with most cultures in Kenya where it is preferable to dress infants warmly all through or keeping infants indoors for certain number of months before the child is taken to public places. Thereby, all children should be exposed to adequate sunshine while naked or with minimal clothing for at least 30 minutes per week, for the children to get adequate vitamin D (Kinuthia et al. 1994; Kreiter et al. 2000). In urban areas, sunbathing should be promoted and open spaces left deliberately to allow sun rays exposure for the benefit of public.

The current findings also implicate feeding of children on breakfast cereals and porridge made of multiple cereal mixes as risk factors towards development of rickets; children fed on breakfast cereals and multiple flour mixes were 3.9 and 6.7 times at a greater risk,

respectively. Research on the potential role of different cereals on the aetiology of rickets in animal models was conducted since the early 1900s (Thomas & Steenbock 1936). The study showed that greater proportion of cereals in infants diet led to increased risk towards rickets. The whole grain cereals have rachtogenic action due to high levels of phytin-phosphorus (phytin-P) which binds to calcium salts leading to less bio-available complex compared to calcium phosphate (Bruce & Callow 1934). The rachitogenic/anticalcifying action in cereals can be counteracted through processing and fortification of cereals with calcium salts and vitamin D (Joint WHO/Flour fortification Initiative 2012). Fortification has a great beneficial impact to health (Andang'o et al. 2007; Das et al. 2013). Flours are mandatory fortified with calcium in United Kingdom and voluntarily in Canada and USA (Joint WHO/Flour fortification Initiative 2012). Flour millers in Kenya have adopted the national fortification scheme (Nystrom et al. 2003; Mugambi 2013), but still, documentation of fortification of cereals in Kenya with calcium or fats/oils with vitamin D is not available (MOST/USAID 2017). However, porridge flours fortified with calcium in the Kenyan market are available. Home-based techniques to improve micronutrient bio-availability grains such as germination, soaking and fermentation have been shown to work (Hotz & Gibson 2001) and can be easily adopted at household-level or cottage/artisanal industries (Frontela et al. 2011). Also similarly, addition of oil can also increase bioavailability of calcium by the formation of calcium soap a step occurring prior to formation of calcium phytin complex (McDougall 1938). The addition of margarine or butter in children porridge is a common practice in Kenya. This practice of adding margarine should be promoted for it also enriches food with calories, vitamin D and essential oils while home-based/artisanal processing of cereals should be taken-up to create novel products that boost micronutrient intake.

Since it may be difficult to reconstruct new urban buildings with ample sunbathing opportunities, poor dietary intake of calcium and vitamin D by under-fives, which results in rickets can be prevented by supplementation of under-fives and pregnant/lactating mothers with vitamin D and calcium, in addition to routine deliberate sunbathing. Infant foods that rely on multiple un-precooked cereals should be discouraged and locally available single fortified or unfortified cereals such as maize, sorghum, millet, or wheat flours encouraged. Enrichment of the cereals with milk or margarine should be promoted. Fortification of cereals is current practice in Kenya, but milk in Kenya is not fortified and could be a good vehicle for fortification with Vitamin D since milk was consumed by 88 % of cases and 98 % of controls.

Conclusion and recommendation

Rickets among under-fives in Kenya is associated with early introduction of complementary foods, short period of exclusive breast feeding, complementary foods that are low in Calcium or Vitamin D, lack of exposure to the sunlight as a result of living in high-rise buildings. Vitamin D supplementation such as giving children a teaspoon of cod liver oil routinely or calcium fortified flours can go a long way in reducing cases of rickets.

Furthermore, there is need to educate mothers on the importance of vitamin D in the body; for instance mothers need to know that vitamin D promotes child development, bone mineralization as well as development and maintenance of a strong immune system. Households should put great effort in making sure they include calcium and Vitamin D rich foods in the diets. In addition, they should be clearly advised against utilization of mixed cereal/legume flours for making baby foods for they have different cooking durations and some are loaded with anti-nutrients. The government agencies and development partners should promote the consumption of calcium and vitamin D rich foods, establish supplementation programs with Vitamin D, and strengthen fortification programmes to also include calcium in baby foods. The city engineers and developers should ensure that there is adequate public open spaces and building that allow for sunbathing and recreational activities since majority of the population live in urban areas.

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