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

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Abstract

The objective of this study was to determine child feeding patterns of calcium and vitamin D rich foods as well as child care practices in relation to rickets among under-fives in an area dominated by dairy industry and sunlight Kiambu County, Kenya. An unmatched case-control study design was used. The case group comprised of children with rickets while the comparison group was children without rickets. Each group consisted of 200 children selected when they attended treatment at the Kiambu Level Four Hospital. Child care practices as well as demographic, socio-economic and other contextual characteristics of child's household were assessed using a pretested structured questionnaire. Dietary calcium, phosphorus and vitamin D intake was determined using a single 24 hour dietary recall method and nutrient intakes computed using Nutrisurvey. Inadequate intake of calcium and vitamin D rich foods was observed. The mean intake of calcium and vitamin D was 190.7±114.1 mg/day and 0.02±0.05 µg/day, respectively, all below RDA. Significant risk factors towards rickets were consumption of breakfast cereals (OR 3.8) and porridge made with multiple cereal/legume composite flours (OR 6.7). Daily child exposure to sunlight (OR 0.035), consumption of meat (OR 0.34) and living in open residential houses (OR 0.42) were significant protective factors against rickets. Simple sunbathing of children is a powerful way of eradicating rickets in low income economies. Policy makers should take action on mushrooming unplanned urban areas and design of residential houses due to impact on health of public and explore under fives calcium and vitamin D supplementation.

Keywords: 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 (Allgrove, 2004; Welch et al., 2000), Kenya's urban areas have not

been spared. Overall, 1 billion people in the world have rickets. 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. Nutritional rickets remain prevalent in developing regions of the world such as Africa and Asia. In the recent years, global public health and nutrition interventions are focused primarily on obesity and specific micronutrient interventions while diseases like rickets are neglected. The long-term vitamin D deficiency in children leads to rickets with significant skeletal deformities and poor growth (Dawodu and Tsang, 2012).

The main source of vitamin D for breastfed infants and newborns is placental transfers during before birth, breast milk and sunlight exposure (Hollis and Wagner, 2004). However, the milk of healthy lactating mothers contains relatively low quantity of vitamin D and 25-Hydroxyvitamin D insufficient to prevent vitamin D deficiency in exclusively breast-fed infants if sunlight exposure is limited (Aggarwal et al., 2012; Ala-Houhala et al., 1988; Kreiter et al., 2000; Pugliese et al., 1998; Thacher et al., 1999). Vitamin D stores in infants at birth depends on maternal vitamin D status during pregnancy (Hollis and Wagner, 2004). According to Dawodu and Tsang (Dawodu and Tsang, 2012), vitamin D deficiency could be an under recognized global mother-infant health problem. Vitamin D is naturally synthesized under the skin of mammals exposed to ultra-violet light or sunshine (Aggarwal et al., 2012) while calcium is found in milk and its products, fish, and vegetables. However, majority of the affected persons live in the sun rich regions of world (Bouillon, 2010).

The consequences of insufficient child nourishment continue into adulthood and are passed on to the subsequent generations affecting negatively the community's future physical health, economic well being and welfare. Therefore this study was implemented to determine the extent of the ricket problem and associated factors among under-five children, firstly in the Central region of Kenya and upscale of the research to other parts of the country.

Methods

Study setting

The study was conducted in Kiambu District 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

A case-control study design was used where two hundred children aged 6-59 months with rickets were systematic random sampled at Kiambu District Hospital when attending for health care services during the months of August and September 2011 forming the case group. A similar number of children without rickets were also systematic randomly selected after every 2 child to form the comparison group. All children were selected as they visited the Out-Patient Department, paediatric ward and physiotherapy Division of the Hospital. The sample size calculation was based on the Fleis formula (Fleiss, 1981) for case-control studies, assuming a statistical power of 80%.

Data collection

A pretested structured questionnaire was used to collect data from the respondents who were mothers/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. 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 accuracy in taking readings.

Presence of rickets was determined by physical examination by trained nurse deployed at Kiambu Level Four hospital. Co-morbidities were determined through self-reporting through respondents.

Data was collected through the assistance of research assistants who had been trained on best practices and ethical issues and performed supervised pilot of study protocols. Pretesting of tools for training and improvement on tools was done in Nguriunditu Village, Kikuyu Division. To also ensure quality of data collected, filled questionnaires were reviewed on a daily basis and problems encountered were rectified. This study was approved

by Kiambu Level Four Hospital before start of data collection. Informed consent was obtained from the caregiver/respondent without any coercion.

Data handling and Statistical analysis

Computations of daily nutrient intake from 24 hour dietary recall data was performed using Nutrisurvey software (2007). All data was entered to a database using Statistical Package for Social Sciences (SPSS) software version 16. Data cleaning and statistical analysis were performed using SPSS version 16. Means and standard deviation of vitamin D, calcium and phosphorus daily intakes were computed using descriptive statistics and Chi square test for bi-variate analysis. Logistic regression analysis was used for calculation of odds ratio. 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). Twenty nine percent (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 those without rickets were only 11 % who stopped at this time (p-value <0.001) meaning breastfeeding was stopped earlier for 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. Three percent (3 %) of the cases were introduced to complementary feeds at the age of 1 month.

Table 1: Feeding and child care practices of the study children

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+	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

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 care givers for the rickets children (78.5%) compared to 86.5 % of non rickets children (p-value <0.05) indicating that children raised by mothers were less likely to develop rickets compared to the ones raised by other

care givers. 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 children taken to child welfare clinics was statistically different with children with rickets being 63 % and those without rickets 74%.

The mean daily dietary intake of calcium was 191±114.1 mg (Mean, SD) for children with rickets and 264±114.1 mg (Mean, SD) for children without rickets (p-value=0.002) (Table 2) showing that children with rickets have considerably lower mean dietary calcium intakes. A similar trend is observed for mean daily dietary intake of phosphorus (Table 2). The mean dietary of vitamin D among the study groups was not statistically significant at 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

	With rickets (n=51)		Without rickets (n=49)		
Food nutrient	**Mean±SD**	**95% CI**	**Mean±SD**	**95% CI**	**p value**
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

The frequency 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 seldomly consumed by children from the two groups. Majority of the children suffering from rickets were fed on spinach and breakfast cereal and composite 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	With rickets		Non rickets		χ^2	p-value
	Yes	No	Yes	No		
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
Porridge of multi-cereal mixtures	93	7	66.5	33.5	43.4	**0.000
Breakfast cereal	68	32	41	59	29.4	**0.000

* 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 (%) n=200	Non rickets Frequency (%) n=200
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

Determination of the determinants of rickets in Kiambu County

Univariate logistic regression analysis (Table 5) identified exclusive breast feeding of children (OR 0.4), feeding children meat (OR 0.3), living in bungalows or open houses (OR 0.4), daily sunbathing of children (OR 0.03) as significant protective factors towards rickets. Feeding children with liver and frequent visit to child welfare clinics are potential protective factors since significance level was as not met. However, feeding children on breakfast cereals (OR 3.8) or porridge prepared using multiple cereal/legume (OR 6.7) were identified as risk factors of rickets under-fives. Intake of spinach (OR 1.9, P 0.06) was borderline significantly associated with rickets in underfives.

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=borderline 0.05 ** Highly significant (p<0.01)

Discussion

The current study indicates that males were slightly more than females for the two study groups with a male to female ratio was 1.2:1 which was similar to a study carried out at Kenyatta National Hospital to assess the incidences of rickets where rickets was more predominant in male infants (Kinuthia et al., 1994). Children who were less than one year of age were more susceptible to rickets than the older children concurring with the study conducted at Lady Reading Hospital in Peshawar, Jordan. In the study, 66% children were less than one year of age, 24% were 1-2 years of age, 6% were 2-3 years old, while 4% were above 3 years of age (Khan et al., 2001). This could be associated to less exposure to sunlight for infants. Most cultures in Kenya prefer to keep infants indoors for certain number of

months before the child is taken to public places. In other instances, exclusive breastfeeding is not universally practiced by mothers of children. However, a higher proportion of children in this study area were more exclusively breastfed than the national averages of 32% (UNICEF, 2006), the correlation of exclusive breastfeeding and rickets at a large scale in Kenya has not been performed. WHO (WHO, 2011), recommends that children be exclusively be breast fed for the first 6 months of life. Complementary feeding should only start after 6 months after birth in addition to continued breast feeding until the child is 24 months old. This study, showed that children who are introduced on complementary food early were particularly at risk of developing rickets, those was 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), a low intake of these foods likely explains why the case group was predisposed to rickets over the comparison group (Aggarwal et al., 2012). On the other hand, green leafy vegetables such as spinach contain high calcium content but also have antinutrients 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 phosphorus intake for the rickets cases was 227.6 mg per day and for those without rickets had 332.1 mg per day which was within the recommended intake of 275-500 mg per day. The low intake of calcium and phosphorous through the diet of children also contributed significantly to the difference observed in the prevalence of rickets for the two groups.

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, it is not a staple food in Central Province where the study was conducted. The nature of housing for the majority of children with rickets was multiple storey buildings (flats) where there is less exposure to sun rays. This was also complicated by the fact most caregivers did not take their children for sunbathing. Vitamin D is synthesized in the body in the presence of sunlight hence less synthesed vitamin D3, in human skin. Similar findings

were reported in Pakistan where majority of the rickets children lived in flats while a very small percent lived in open houses (Khan et al., 2001). Thereby, for all children should be exposed to adequate sunshine while naked or with minimal clothing at least 30 minutes per week, for the children to receive required vitamin D (Kinuthia et al., 1994; Kreiter et al., 2000). In these communities, sunbathing should therefore, be promoted and open spaces left deliberately to allow for sun rays to reach the ground to benefit the public.

The current findings also implicate feeding of children on breakfast cereals and porridge made of multiple cereal mixes as risk factors for 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 and Steenbock, 1936). The study reported that the greater the proportion of cereals in infants diet led to increased risk towards rickets (12).The explanation offered was that cereals have rachitogenic/anticalcifying action, and proposed that this can be counteracted by addition of calcium salts and vitamin D. The rachtogenic action of whole grains cereals is due to high levels of phytin-phosphorus (phytin-P) which binds to calcium salt which is less bio-available than calcium phosphate (Bruce and Callow, 1934). Frontela et al., (Frontela et al., 2011) displayed processing methods that reduce phytate content of bakery cereals. Addition of oil can increase bioavailability of calcium by formation of calcium soap prior to calcium forming a complex with phytin (McDougall, 1938). The addition of margarine or butter in children porridge is a common practice in Kenya, and in should be promoted to also enrich the food with calories. In addition, due to the deficiencies as a result of poor dietary intake, pregnant women and under-fives should also be supplemented with vitamin D and calcium since it may difficult to reconstruct new urban buildings with amble sunbathing opportunities. Infant feeds that rely on multiple un-precooked cereals should be discouraged and encourage locally available single cereals e.g. maize, sorghum, millet, or wheat flour which can be enrich with milk or margarine should be promoted

Conclusion and recommendation

Rickets among under-fives in Kenya is associated with early introduction of complementary foods, short period of exclusive breast feeding, low nutritive value of complementary feeds in Calcium or Vitamin D and lack of exposure to the sunlight or living

high-rise buildings. Calcium and vitamin D supplementation or fortification is not an advocacy issue at the moment in Kenya.

Therefore, there is need to educate mothers on the importance of vitamin D that cuts across promoting 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 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 a loaded with antinutrients. The government and other development partners should also promote the consumption of calcium and phosphorus rich foods or by supplementation programmes. The city developers leave public open spaces and building that allow for sunbathing and recreational activities since majority of the population lives in these areas.

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