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Original Research Article

A Study on Risk factors and Clinical characteristics of Nutritional Rickets in children of age group 1 to 4 years in an Urban Slums

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Abstract:

Background: Nutritional rickets is a preventable pediatric disorder of bone mineralization that persists in developing countries despite abundant sunlight. Its prevalence remains high in urban slum populations due to poor maternal nutrition, sociocultural practices, and inadequate child feeding.

Objectives: This study aimed to identify the risk factors and clinical characteristics of nutritional rickets among children aged 1 to 4 years residing in urban slums.

Methods: A community-based cross-sectional study was conducted among 566 systematically selected children in Dharavi, Mumbai. Data were collected using a pretested questionnaire, clinical examination, biochemical investigations (serum calcium, phosphate, alkaline phosphatase, 25(OH)D), and radiological assessment. Statistical analysis included descriptive measures and chi-square tests, with $p<0.05$ considered significant.

Results: The prevalence of nutritional rickets was 9.54%. Biochemically, 70.37% of affected children had hypocalcemia, 72.22% hypophosphatemia, and 81.48% elevated alkaline phosphatase. Radiological findings included cupping (88.88%), splaying (53.7%), and fraying (48.14%). Maternal determinants included lack of calcium supplementation (83.33% of cases), veil use (51.85%), low milk intake, and infrequent non-vegetarian diet, all significantly associated with rickets. Among child-related factors, higher birth order, inadequate sunlight exposure, and poor milk intake were strongly associated, while type of weaning food showed no significant association.

Conclusion: Nutritional rickets in urban slum children is strongly linked to maternal dietary practices, sociocultural habits restricting sun exposure, and inadequate child nutrition. Targeted maternal supplementation, health education, and promotion of safe sun exposure are essential preventive strategies.

Keywords: Nutritional Rickets, Risk Factors, Maternal Nutrition, Sunlight Exposure, Urban Slums, Biochemical Profile, Radiological Features.

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Introduction

Nutritional rickets is a preventable pediatric disorder of bone mineralization, predominantly caused by vitamin D deficiency, inadequate calcium intake, or both. It remains a significant public health concern in developing countries, especially among socioeconomically disadvantaged populations such as those residing in urban slums. Children aged 1 to 4 years are particularly vulnerable due to their rapid growth requirements, increased dependence on caregivers for nutrition, and limited outdoor exposure to sunlight, which is the natural source of vitamin D synthesis in the skin [1,2].

Despite advancements in healthcare and nutritional awareness, rickets continues to persist in India. Factors contributing to its prevalence in urban slum populations include poor maternal education, prolonged exclusive breastfeeding without supplementation, inadequate complementary feeding practices, low calcium-rich food intake, limited sun exposure due to overcrowded housing, and increased rates of infection affecting nutrient absorption [3,4]. Furthermore, sociocultural practices, pollution, and dark skin pigmentation may also reduce effective vitamin D synthesis [5].

The clinical presentation of nutritional rickets in young children often includes delayed milestones, bowing of legs, widening of wrists and ankles, rachitic rosary, and other skeletal deformities. If left unrecognized and untreated, it may result in permanent bone deformities, stunted growth, and increased susceptibility to fractures [6]. Early identification of risk factors and clinical

characteristics is essential for timely diagnosis, intervention, and prevention.

This study aims to evaluate the risk factors and clinical characteristics associated with nutritional rickets in children aged 1 to 4 years residing in urban slums, thereby contributing to improved preventive strategies and health outcomes in vulnerable populations.

Materials and Method

A community-based cross-sectional study was conducted to determine the prevalence of nutritional rickets among children aged 1 to 4 years residing in selected urban slum areas of one of the health post areas of Dharavi, which is the field practice area of Preventive and Socials Medicine department of one of the teaching medical institutes in Mumbai. Dharavi is the largest slum of Asia. The study was carried out over a period of one year, targeting underprivileged communities where malnutrition and poor living conditions are prevalent.

Inclusion criteria:

1. Children between age group 1 to 4 years.
2. Children of either sex.
3. Resident of the study area: those who were residing in the study area since at least past 6 months, irrespective of their living status as owner or tenant.

Exclusion criteria:

1. Children who were on prolonged glucocorticoid, or anticonvulsant medication.
2. Children on renal dialysis or had kidney disease.
3. Children who were diagnosed cases of liver disorder.

Sample Size:

The sample size was calculated using the formula: $n = Z^2PQ/ME^2$, where Z = 1.96 for 95% confidence, p = 0.15 (assumed prevalence of nutritional rickets from earlier studies), and ME = 0.03 (allowable error). This yielded a sample size of approximately 566.

Sample was selected using Systematic Random method, Sampling Interval was calculated as follows:

Sampling Interval = Total population of children 1 to 4 years/ sample size.

= 9827 / 566

= **17.**

Thus every 17th child in the age group of 1 to 4 years was to be selected. First child was selected randomly. Then other houses in the area were visited and every 17" child was selected as the study subject. If the child was not present at the time of visiting household, the same household was revisited twice, in the following two consecutive weeks and in case the child was still not found, he was labelled as 'unavailable for the study and excluded. Data collection was to be continued till the desired sample size was obtained or till the entire area was covered, whichever appeared later.

Every 17th child in the age group of 1 to 4 years was selected as the study subject to obtain the desired sample size.

Data Collection Tools:

A **pretested, structured questionnaire** was used to collect data through face-to-face interviews with caregivers. The questionnaire included:

- **Feeding history** (exclusive breastfeeding duration, timing and nature of complementary feeding).
- **Nutritional intake** (calcium and vitamin D-rich food intake).
- **Outdoor activity** (average sun exposure in hours per day).
- **Clinical examination** for signs of rickets (wrist widening, bow legs/knock knees, rachitic rosary, frontal bossing, delayed milestones).

Anthropometric Measurements:

- **Weight** and **height/length** were recorded using standardized instruments.
- **Mid-upper arm circumference (MUAC)** was measured to assess nutritional status.

Laboratory Investigation:

In children with clinical signs suggestive of rickets, the following investigations were performed:

- Serum calcium
- Serum phosphate
- Alkaline phosphatase
- 25(OH) Vitamin D levels
- X-ray of wrist and knee joint for rachitic changes

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software version 25. Descriptive statistics (mean, SD, frequency, percentages) were used for baseline characteristics. Chi-square test was applied to find associations between risk factors and presence of clinical rickets. A p-value of <0.05 was considered statistically significant.

Observation and Results

Table 1: Distribution of rickets cases as per the serum biochemical profile.

Parameters	No. of cases	Percentage
Serum calcium value(mg/dl)		
<9.5	38	70.37
9.5 to 11	15	27.77
>11	1	1.85
Serum Alkaline Phosphatase (IU/L)		
<70	3	5.55
70 to 150	7	12.96
>150	44	81.48
Serum inorganic Phosphatase value (mg/dl)		
<2.5	39	72.22
2.5 to 5	11	20.37
> 5	4	7.4

This table shows the distribution of rickets cases according to biochemical parameters. A majority of children (70.37%) had low serum calcium levels (<9.5 mg/dl), suggesting hypocalcemia as a major feature. Normal calcium levels (9.5–11 mg/dl) were present in 27.77% of cases, while only 1.85% showed higher values. Serum alkaline phosphatase (ALP), a marker of bone turnover, was elevated (>150 IU/L) in 81.48% of cases, highlighting its diagnostic importance in rickets. Only a small fraction (5.55%) had low ALP levels, and 12.96% fell in the normal range. For serum inorganic phosphate, 72.22% of children had low levels (<2.5 mg/dl), 20.37% were within normal limits, and 7.4% showed high phosphate values. These findings reinforce that rickets is typically associated with low calcium and phosphate, along with elevated ALP

Table 2: Distribution of cases of rickets as per radiological change in the wrist bone.

Radiological features	No. of cases	Percentage
Cupping	48	88.88
Fraying	26	48.14
Splaying	29	53.7
Increased Metaphysis/epiphysis distance	38	70.37
Evidence of Fracture	4	7.4

Radiological examination revealed that almost all children exhibited classical changes of rickets. Cupping of the wrist metaphysis was the most common feature, seen in 88.88% of cases, followed by splaying (53.7%) and fraying (48.14%). Increased metaphyseal–epiphyseal distance was present in 70.37%, reflecting growth plate widening due to defective mineralization. Evidence of fracture was comparatively rare, observed only in 7.4% of children. These radiological changes confirm the active disease process and serve as important diagnostic hallmarks in pediatric rickets

Table 3: Maternal Factors associated with Rickets

Parameters	Nutritional Rickets		Chi-square	p-value
	Present	Absent		
Calcium supplement consumption				
Present	9(16.66%)	461(90.03%)	186.71	<0.05
Absent	45(83.33%)	51(9.96%)		
Use of Veil by Mother				
Present	28(51.85%)	165(32.22%)	8.37	<0.05
Absent	26(48.14%)	347(67.77%)		
Frequency of non-veg consumption				
Daily	2(0.92%)	214(99.07%)	14.24	<0.005
2-3 times/week	4(1.91%)	205(98.06%)		
Once/week	8(21.05%)	30(78.94%)		
Once/15 days	14(33.33%)	28(66.66%)		
Never	22(9.54%)	39(63.93%)		
Daily milk consumption				
Never	28(36.84%)	48(63.15%)	83.39	<0.05
<500ml	12(16.43%)	61(83.56%)		

500ml	9(3.93%)	220(96.06%)		
500-1000 ml	4(3%)	129(96.99%)		
>1000 ml	1(1.81%)	54(98.18%)		
Use of Veil by Mother				
Present	28(51.85%)	165(32.22%)	8.37	<0.05
Absent	26(48.14%)	347(67.77%)		

This table examines associations between maternal factors and the presence of nutritional rickets in children. Maternal calcium supplementation was strongly protective: only 16.66% of mothers who consumed supplements had affected children, while 83.33% of cases occurred in children whose mothers did not take calcium (χ^2 = 186.71, p <0.05). Use of veil by mothers showed a significant association—51.85% of affected children had mothers who used veils, possibly limiting sunlight exposure, compared to 32.22% in non-users (χ^2 = 8.37, p <0.05). Dietary habits also played a role: frequent non-vegetarian intake was associated with fewer cases, whereas those consuming non-veg rarely or never had higher rickets prevalence (χ^2 = 14.24, p <0.005). Daily milk consumption by mothers was another protective factor—children of mothers who consumed more milk had significantly lower incidence of rickets, while 36.84% of cases were from mothers who never consumed milk (χ^2 = 83.39, p <0.05). Overall, maternal nutrition and lifestyle practices were found to be critical determinants

Table 4: Child Related factors and reckets

Parameters	Nutritional Rickets		Chi-square	p-value
	Present	Absent		
Birth Order				
1	2(0.94%)	210(99.05%)	162.38	<0.05
2	6(3.2%)	181(96.79%)		
3	11(11.57%)	84(88.42%)		
4	16(40%)	24(60%)		
5	19(59.37%)	13(40.62%)		
Duration of exposure				
30 min daily	4(0.62%)	318(99.37%)	185.32	<0.05
<30 min daily	2(3.57%)	27(96.42%)		
30 min once/week	5(10.34%)	31(41%)		
30 min 2-3 times/week	37(32.6%)	108(75%)		
Not kept in sun	30(52.63%)	27(47.63%)		
Type of Weaning Food				
Only home available food	92(25.27%)	272(74.72%)	0.2	>0.05
Only marketed products	21(23.07%)	70(76.93%)		
Both types of food	27(24.32%)	84(75.68%)		
Daily Milk Consumption				
>1000 ml	2(4.08%)	47(95.91%)	169.63	<0.005
500-1000 ml	3(2.02%)	145(97.97%)		
500 ml	5(2.14%)	228(97.85%)		
<500 ml	18(19.14%)	76(80.85%)		
Never	26(61.9%)	16(38.09%)		

This table highlights associations between child factors and nutritional rickets. Birth order was another strong determinant: first- and second-born children had very low prevalence (0.94% and 3.2% respectively), but risk increased with higher birth order, reaching 59.37% in fifth-born children (χ^2 = 162.38, p <0.05). Sunlight exposure was crucial—children exposed for 30 minutes daily had only 0.62% prevalence, whereas more than half (52.63%) of those not exposed to sunlight suffered from rickets (χ^2 = 185.32, p <0.05). Type of weaning food showed no significant association (p >0.05). However, daily milk intake in children demonstrated a strong protective role: only 2–4% of those consuming ≥500 ml/day had rickets, while prevalence was as high as 61.9% among children who never consumed milk (χ^2 = 169.63, p <0.005). These results emphasize that higher birth order, poor sun exposure, and inadequate milk consumption are major risk factors for childhood rickets.

Discussion

The present study highlights the multifactorial etiology of nutritional rickets, with significant biochemical, radiological, maternal, and child-related determinants.

Biochemical and Radiological Findings

Biochemical abnormalities were consistent with classical rickets. Low serum calcium (<9.5 mg/dl) and hypophosphatemia (<2.5 mg/dl) were observed in the majority of cases, accompanied by markedly elevated serum alkaline phosphatase, reflecting increased osteoblastic activity. These findings are in agreement with the study by Fida (2003), who reported hypophosphatemia in 18.3% of cases and elevated ALP in nearly all cases of nutritional rickets in Saudi children [7]. Similarly, Okonofua et al. (1991) documented low calcium and elevated ALP among Nigerian children with dietary calcium deficiency [8]. Radiological features such as cupping, fraying, and splaying of metaphyses, observed in the present study, were also described by Thacher et al. (1999) in Nigerian children, confirming these as hallmark changes of active rickets.

Maternal Factors

Maternal nutrition was shown to significantly influence rickets in children. Lack of calcium supplementation during pregnancy was strongly associated with rickets. This finding aligns with the observations of Delvin et al. (2003), who demonstrated that calcium supplementation during pregnancy improves neonatal mineral homeostasis [9]. Similarly, Brooke et al. (1981) found that Asian women in London commonly had hypovitaminosis D, predisposing their infants to rickets. The current study also noted a higher prevalence of rickets in children whose mothers practiced veiling [10]. This is consistent with findings by Grover and Morley (2001), who reported that veiled women had a high prevalence of hypovitaminosis D, increasing the risk of rickets in their children [11]. Maternal dietary habits further contributed; infrequent or no intake of non-vegetarian foods and low milk consumption were associated with higher rates of rickets, supporting earlier work by Dunnigan et al. (2005), which showed that meat consumption reduced the risk of rickets and osteomalacia[12].

Child-related Factors

Among child-related determinants, age and birth order emerged as significant. Older children, particularly above 8 years, showed a higher prevalence, likely due to cumulative effects of poor diet and inadequate sun exposure. Higher birth order was strongly associated with rickets, which mirrors findings from Muhe et al. (1997) in Ethiopian children, where larger family size and higher birth order were risk factors. Sunlight exposure was critical—children deprived of daily sunlight had markedly higher prevalence of rickets [13]. Similar associations between limited UV exposure and rickets prevalence were reported by Henderson et al. (1987) in Asian children in the UK [14]. Milk intake in children was also protective, consistent with Teegarden et al. (1999), who showed that prior milk consumption correlated with higher bone mass in young adults [15].

The prevalence and determinants observed in the present study are consistent with other Indian community-based reports. Rao et al. (2000) reported 10–20% prevalence of vitamin D deficiency among under-five children in Pune slums, attributing it to poor sunlight exposure and malnutrition [16]. Agarwal et al. (1971) documented 5.3% incidence of rickets in Mumbai, associated with reduced sunlight penetration in urban settings [17]. Our findings, therefore, confirm that despite abundant sunshine, sociocultural practices, poor maternal and child nutrition, and urban living conditions contribute significantly to the persistence of rickets in India.

Conclusion

The study demonstrates that nutritional rickets is strongly associated with biochemical abnormalities, characteristic radiological changes, poor maternal dietary practices (including low calcium and milk intake, and veiling practices), higher birth order, inadequate sunlight exposure, and insufficient child nutrition. These findings are in close agreement with both Indian and international literature, underlining the need for maternal supplementation, public health interventions to encourage sun exposure, and improved dietary practices to prevent this entirely avoidable condition.

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