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Research Article

A Community-Based Study of Milk Adulteration and Childhood Malnutrition in Bangalore Rural District, India

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ABSTRACT

Background: Milk promotes child growth; however, adulterated milk reduces nutritional value and exposes children to harmful chemicals. Therefore, this study aimed to assess the nutritional status of children aged 1–5 years living in the selected study area and test milk samples from the children's households for common adulterants. The study further aimed to explore the association between malnutrition and milk adulteration.

Methods: We used a community-based cross-sectional study design conducted in the service area of a tertiary healthcare institute in Bangalore Rural District, Karnataka state, India. Systematic random sampling was used to recruit 180 children aged 1–5 years. Primary data was collected through interviews, anthropometry, and strip tests for milk adulteration. Statistical analysis consisted of descriptive analysis, Chi-square tests, odds ratios, and 95% confidence intervals.

Results: Prevalence of underweight, stunting, wasting, and low Body Mass Index (BMI) was 13.33%, 38.33%, 15.0%, and 26.7%, respectively. General adulterants detected were neutralizers in 97 (53.9%) and maltodextrin in 90 (50%) samples. Higher proportions of stunting, underweight and low BMI were found in children drinking adulterated milk. Low BMI was significantly associated with joint family and lower maternal education.

Conclusion: Our study found a high prevalence of malnutrition in children, particularly stunting. The study also detected widespread adulterants in milk and a potential association with malnutrition. The authors recommend further studies with a larger sample size to accurately delineate the relationship between milk adulteration and malnutrition.

Keywords: Malnutrition; Milk adulteration; Under-five; Stunting; Underweight; Wasting

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INTRODUCTION

In India, 38 percent of under-5 children are stunted, a manifestation of chronic undernutrition. Malnutrition is responsible for nearly half of all child deaths globally (1). There are significant inequalities across states and socioeconomic groups, with rural areas and the poorest people being the worst affected (2). Bangalore Rural District in Karnataka state is below expected standards in key indicators of nutrition. The National Family Health Survey 2015-16 (NFHS-4) results reveal stunting in 38.5% of under-five children, wasting in 26.9%, and underweight in 37.7%, a worrisome prevalence (3).

In the Indian population, approximately 12% of the dietary intake consists of milk and food products derived from milk (4). In Karnataka state, as much as one-fifth (22.2%) of the population is lactovegetarian which means milk is the only source of animal-based protein for these families and their children (5). However, research has revealed that approximately 80% of children in the 1–6 years age group in Karnataka consume less than 50% of the recommended daily intake (RDI) of milk and milk-based foods (6). Undernourished children who regularly drink milk show better growth and cognition and improvements in biochemical and functional indicators of nutrition, thereby enhancing health and reducing mortality (7). However, adulterated milk is a serious public health issue, with around 68.7 percent of milk not satisfying the standards of the Food Safety and Standards Authority of India (FSSAI) (8). Adverse consequences of drinking adulterated milk are well documented worldwide (9–11).

Therefore, in our capacity as public health researchers working in a tertiary healthcare institution, we proposed the present study. Our objectives were to assess the nutritional status of children aged 1–5 years, to test milk samples from the children's households for common adulterants, and further to explore the association of milk adulteration with malnutrition in children so that baseline data could be made available and utilized in future to confront these two important public health issues.

METHOD

This study was designed as a community based cross-sectional study in the catchment area of the Rural Health and Training Centre (RHTC) of a tertiary health institute. The RHTC serves a total population of over 25000, of which around 2500 were estimated to be children aged five years or less (approximately 10% based on Census 2011 data) (12). Among this group, children aged 1-5 years were included in the study as infants may be largely dependent on maternal nursing.

We calculated a sample size of 180 based on an initial estimate of 150 using the formula $n = z^2P(1-P)/d^2$,(13) taking z = 1.96 at 95% confidence level, d = 0.05, P = 0.11 taking 11% prevalence of severe wasting based on NFHS-4 data (3) and adding 20% for non-response. The inclusion criteria were age 1-5 years, residence in the area for at least the past six months, and the guardian's consent for the child to participate in the study and provide a sample of raw milk purchased the same day for testing.

We carried out a house-to-house survey, using systematic random sampling, and collected data using a pretested objective questionnaire administered to the mothers of the selected children, or if the mother was absent, the following primary caregiver. The questionnaire contained basic identifier data, followed by education, occupation and income, and health-related information such as vaccination status, breastfeeding, recent illnesses, and others. This was followed by obtaining a sample of raw milk for testing and anthropometric assessment of weight and height/length as described in the World Health Organization (WHO) child growth standards training manual (14). Milk was tested for the presence of water, starch, urea, and detergent using methods recommended by FSSAI (15) and for maltodextrin, hydrogen peroxide, and neutralizers using strip tests, developed through technology transfer from National Dairy Research Institute (NDRI) (16).

Raw data were tabulated and cleaned. Descriptive analysis was performed using classifications such as age group, educational level, and economic class. Socioeconomic status was coded using Modified Prasad's Socioeconomic Scale criteria (17). Milk adulteration was defined according to FSSAI criteria (15). Underweight was defined as Weight for Age (WFA) less than two standard deviations (-2SD) below the median of the WHO Child Growth Standards (WHOCGS), Stunting as Height for Age (HFA) less than 2SD below the WHOCGS median, and Wasting as Weight for Height (WFH) less than 2SD below the WHOCGS median. Bivariate analysis was done using Chi-square tests. Odds ratios and 95% confidence intervals were derived.

Ethical clearance for the study was obtained from the Institutional Ethics Committee of Akash Institute of Medical Sciences and Research Centre, Devanahalli, Karnataka (Reference ID AIMSRC/RP/EC/14/2019).

RESULTS

Demography

We studied 91 girls and 89 boys, of mean age 29.3 7± 13.72 (SD) months. The age and gender distribution of the study sample are shown in Figure 1.

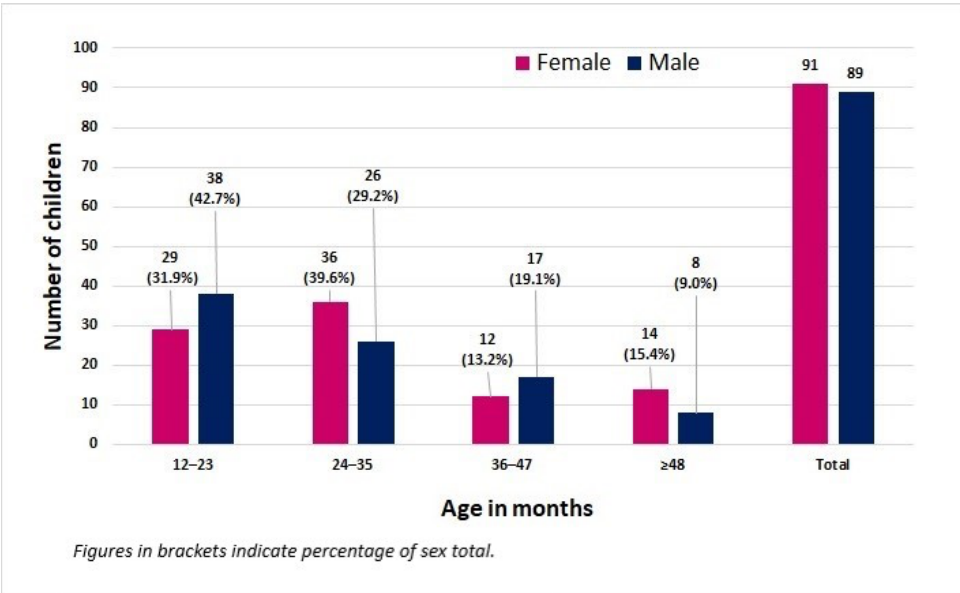

Figure 1. Age and gender distribution of the study participants

Among the 180 children, 67 (37.2%) belonged in the 12-23 months age group. The nuclear family was the predominant family type, with 115 (63.9%) children in this category. Almost all the children, viz., 175 (97.2%), fell in the lower and lower-middle-class socioeconomic category. (Table 1)

Table 1. Socio-demographic profile of the participants

Characteristic	Frequency (N=180)	Percentage (%)
Religion		
Hindu	170	94.4
Muslim	10	5.6
Christian	0	0.0
Type Of Family		
Nuclear	115	63.9
Joint	65	36.1
Socio-Economic Status*		
High	0	0.0
Upper Middle	5	2.8
Lower Middle	55	30.5
Upper Lower	111	61.7
Lower	9	5.0
Mother's Education		
Illiterate	7	3.9
Primary	46	25.6
Secondary	127	70.6
Father's Education		
Illiterate	11	6.1
Primary	48	26.7
Secondary	121	67.2
Mother's Occupation		
Unemployed/ Homemaker	173	96.1
Employed	7	3.9
Father's Occupation		
Unemployed/ Homemaker	2	1.1
Employed	178	98.9

**As per Modified Prasad's Socioeconomic Scale*

127 (70.6%) mothers and 121 (67.2%) fathers had received secondary level education among the parents. Most of the mothers were homemakers, and most fathers were employed in occupations outside the home.

Anthropometry

We did not note any significant gender differences in underweight, stunting, and wasting. Assessment of Body Mass Index (BMI) as per WHO BMI standards showed a statistically significant gender difference with more boys being overweight/obese compared to girls (16/89 boys; 17.97% vs 5/91 girls; 5.49%, chi-square = 6.8, df = 1, P = 0.009, OR = 3.77, $95\%CI_{OR}$ = 1.32–10.79).

Table 2 shows the proportions of underweight, stunting, and wasting observed in the study participants.

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Table 2. Anthropometric indices of the participants

Characteristic	Male (N=89) n (%)	Female (N=91) n (%)	Total (N=180) n (%)
Weight For Age (WFA)*			
Underweight (median-3SD <WFA <median-2SD)	9 (10.11)	13 (14.29)	22 (12.22)
Severely Underweight(WFA <median-3SD)	0 (0.0)	2 (2.19)	2 (1.11)
Overweight (WFA>median+2SD)	4 (4.49)	1 (1.09)	5 (2.78)
Height For Age (HFA)†			
Stunted (median-3SD <HFA < median-2SD)	22 (24.68)	20 (21.98)	42 (23.33)
Severely stunted (HFA < median-3SD)	13 (14.60)	14 (15.40)	27 (15)
HFA > median+2SD	0 (0.0)	2 (2.19)	2 (1.11)
HFA >median+3SD	2 (2.19)	7 (7.69)	9 (5)
Weight For Height (WFH)‡			
Wasted (median-3SD <WFH< median-2SD)	7 (7.86)	4 (4.39)	11 (6.11)
Severely wasted (WFH< median-3SD)	11 (12.36)	5 (5.49)	16 (8.89)
WFH>median+2SD	4 (4.49)	0 (0.0)	4 (2.22)
WFH >median+3SD	8 (8.99)	0 (0.0)	8 (4.44)
Body Mass Index (BMI)§			
Underweight (<18.5)	28 (31.46)	20 (21.97)	48 (26.7)
Healthy Weight (18.5–24.9)	45 (50.56)	66 (72.53)	111 (61.7)
Overweight (25.0–29.9)	4 (4.49)	2 (2.20)	6 (3.3)
Obese (≥30.0)	12 (13.48)	3 (3.30)	15 (8.3)

**Underweight: weight for age (WFA) less than WHOCGS median-2SD*
†Stunting: height for age (HFA) less than WHOCGS median-2SD
‡Wasting: weight for height (WFH) less than WHOCGS median-2SD
§ BMI: As per WHO BMI standards

Milk adulteration

A striking proportion of the milk samples in our study, 158 out of 180 (87.8%), were adulterated with water and/or other chemicals, with neutralizers being the most common adulterant. Urea as an adulterant was not detected in any sample (Figure 2A). We observed that 65 (36.1%) milk samples had two types of adulterants mixed, followed by any one type of adulterant in 58 (32.2%) milk samples (Figure 2B).

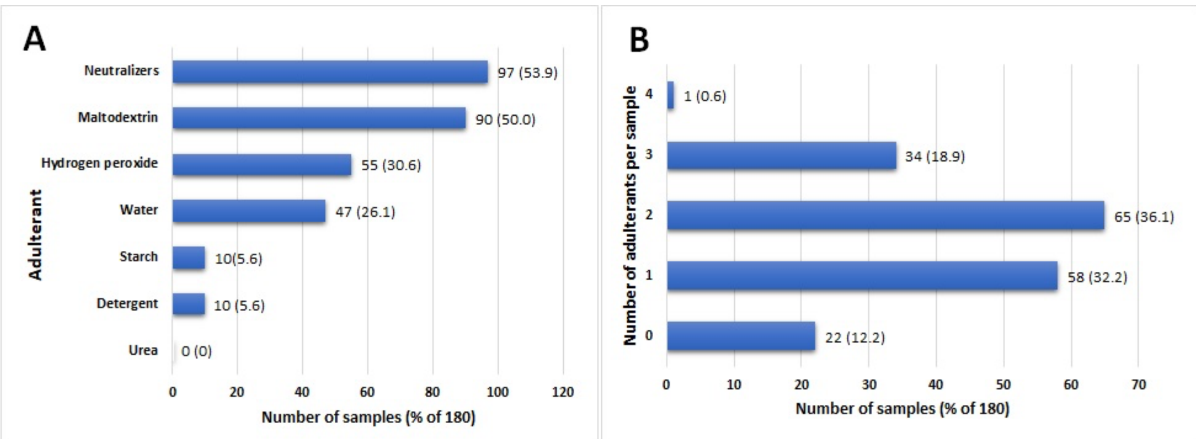

Figure 2. Types of adulterants (A) and Presence of multiple adulterants (B) in milk samples

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Association between malnutrition and adulteration

The proportions of underweight, stunting and low BMI were higher among children drinking adulterated milk, although these differences were not statistically significant. The proportion of wasting was found to be higher in children drinking unadulterated milk. This difference was also not statistically significant (Table 3).

Table 3. Association between adulteration and malnutrition

Variable: Underweight (WFA < median-2SD)	Normal		Underweight		Total		χ 2	P value
	n	%	n	%	n	%		
Unadulterated milk	20	90.91	2	9.09	22	100	0.39	0.532
Adulterated milk	136	86.08	22	13.92	158	100		
Total	156	86.67	24	13.33	180	100		
Variable: Stunting (HFA < median-2SD)	**Normal**		**Stunted**		**Total**		**χ 2**	**P value**
	n	%	n	%	n	%		
Unadulterated milk	15	68.18	7	31.82	22	100	0.45	0.502
Adulterated milk	96	60.76	62	39.24	158	100		
Total	111	61.67	69	38.33	180	100		
Variable: Wasting (WFH < median-2SD)	**Normal**		**Wasted**		**Total**		**χ 2**	**P value**
	n	%	n	%	n	%		
Unadulterated milk	18	81.82	4	18.18	22	100	0.199	0.656
Adulterated milk	135	85.44	23	14.56	158	100		
Total	153	85.00	27	15.00	180	100		
Variable: Low BMI (BMI < 18.5)	**Normal**		**Low BMI**		**Total**		**χ 2**	**P value**
	n	%	n	%	n	%		
Unadulterated milk	17	77.27	5	22.72	22	100	0.199	0.656
Adulterated milk	115	72.78	43	27.22	158	100		
Total	132	73.33	48	26.66	180	100		

Socio-demographic associations of malnutrition

We noted that odds of being undernourished were significantly lower in children living in nuclear families and significantly higher in children whose mothers were not educated beyond primary school level (Table 4).

Table 4. Association between socio-demographic variables and malnutrition

Socio-demographic variables	Undernourished (BMI < 18.5)		Not Undernourished (BMI ≥ 18.5)		Total	$\chi 2$; *P*-value	OR; 95% CI_{OR}
	n	%	n	%			
Family type							
Nuclear	25	21.7	90	78.3	115	3.95; 0.047	0.507; 0.258–0.996
Joint	23	35.4	42	64.6	65		
Mother's education							
Primary	21	39.6	32	60.4	53	6.448; 0.011	2.431; 1.212–4.872
≥Secondary	27	21.3	100	78.7	127		

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DISCUSSION

The present study reported the overall prevalence of underweight/undernutrition, stunting, wasting, and low BMI as 13.33%, 38.33%, 15.0%, and 26.7%, respectively. This is similar to the findings of the study by Meshram et al. (18) among under-5 children in Surat, Gujarat. A notable finding of our study is that there were no significant differences in undernutrition between boys and girls, which points towards the absence of discrimination against girls in feeding and care. However, there was a marked gender difference in the overweight/obese category, significantly more boys than girls. This finding indicates that while girls may not be overtly mistreated, boys are still possibly receiving preferential care related to feeding and household chores.

The observed prevalence of stunting (38.33%) in this study suggests widespread chronic malnutrition in our study population. This was consistent with findings of studies done by Sahoo et al. (42.2%) (19) and Popat et al. (46.1%) (20). Most children in this study, viz 115 (63.9%), belonged to nuclear families. Malnutrition was found to be more common in children from joint families compared to nuclear families. Similar findings were reported by Gopinath et al. (21) and Kodavanti Rao et al. (22).

This study also revealed a significant association between a mother's education and a child's BMI, which is concordant with results reported by Sahoo et al. (19) and Mittal et al. (23). This finding can be attributed to educated mothers having better knowledge about breastfeeding, complementary feeding, and immunization, which would profoundly affect the child's nutritional status. This is supported by research findings from India and other countries (24–29).

The commonest adulterants detected in our study were neutralizers found in 97 (53.9%) samples and maltodextrin found in 90 (50%) samples. In rural areas, dairy farms may not be modernized, and the cold chain may be faulty, leading to milk spoilage. Sowmya et al. observed that middlemen add neutralizers to extend the shelf life of milk by neutralizing the acids produced by bacterial activity, which can maximize the seller's profit but cause significant harm to consumers, especially children (30). The National Milk Safety and Quality Survey 2018 report has also noted the presence of maltodextrin in 156 (out of 6432) samples (31). The report notes that while these may not directly threaten health, such instances of adulteration must nevertheless be prevented by instituting stringent curbs.

Hydrogen peroxide was the next most common adulterant, found in 55 (30.6%) samples. Researchers have documented the longstanding and worldwide use of hydrogen peroxide (H_2O_2) as an adulterant in milk to preserve and lengthen its shelf life. (32, 33). However, it is not desirable to have this contaminant either in trace amounts as a residue of cleaning or due to active adulteration by profiteers. The addition of peroxides and detergents to milk may be responsible for symptoms of gastro-intestinal distress (34).

This study showed that 47 (26.1%) of our milk samples were diluted with added water. According to Handford et al., the FSSAI 2012 national survey had reported extensive use of water to adulterate milk, making it the most common milk adulterant in India. This practice results in low-quality milk with poor nutritional value (9). Similarly, Grace et al., in their study on milk safety in North East India, reported finding water used to dilute milk in samples from all dairies (35).

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This study shows a trend of higher proportion of stunting, underweight and low BMI in the children drinking adulterated milk compared to those who drank milk without any detectable adulterants. However, our results were not found to be statistically significant. The consistent trend of these indicators of malnutrition showing higher prevalence in children drinking adulterated milk is a pointer to the deleterious effect of adulterants, even in trace quantities, on young children. Handford et al. echo this concern, stating that diluting milk with water harms its nutritional value. This may lead to severe challenges with malnutrition in infants and children (9). In India, milk is a chief source of protein for a largely vegetarian population. We must consider the possibility that the extensive prevalence of milk fraud in India, as reflected in the FSSAI 2012 milk safety survey, could be a causative factor in childhood malnutrition (36).

The proportion of wasting in this study did not follow a similar trend of being higher in children drinking adulterated milk. However, wasting is related to acute nutritional deficiencies and infectious diseases compared to stunting, which is an indicator of chronic malnutrition. There may be confounding factors at play in the scenario of acute malnutrition, which may mask the effect of milk adulteration. Thus, stunting may be a more appropriate indicator of the effects of long-term consumption of diluted/contaminated milk that is nutritionally subpar and exposes the child to prolonged, sub-lethal doses of various harmful adulterants.

A fundamental limitation of this study was that testing for milk adulterants was qualitative. The strip tests used in this study only indicated the presence or absence of adulterants and not the concentration in which they were present. Resource and feasibility constraints prevented quantitative analysis from assessing the exact amount of each adulterant in the samples. We observed a high proportion of adulterated milk samples, which resulted in correspondingly very few unadulterated samples. This may have affected the statistical analysis, in which a specific minimum count is required in each cell for the tests of association to be dependable.

CONCLUSION

This study attempts to elucidate the relationship between milk adulteration and childhood malnutrition. The key findings of this study were a high percentage of stunting (38.33%), low BMI (26.7%), wasting (15%), and underweight (13.33%) among children, and an alarming presence of adulterants in nearly 90% of the milk samples tested. Undernutrition was significantly associated with joint family and lower maternal education, and a potential association was detected between malnutrition and milk adulteration. Our findings emphasize the importance of maternal education. The results of this study warrant further research with larger sample sizes to accurately delineate the relationship between milk adulteration and malnutrition, and quantitative analysis of adulterants to gain a clearer picture of the extent of adulteration dose-response relationship, if any, between various adulterants and malnutrition.

Authors' contribution

AM: research design, analysis, and manuscript writing; ID: data collection, analysis, and manuscript writing; RPK: manuscript writing; NN: research design, data collection; PR: analysis.

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Conflict of interest

The authors declare that there are no conflicts of interest.

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