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RESEARCH ARTICLE
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ASSOCIATION OF FAECAL PH WITH CHILDHOOD STUNTING

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Abstract

Background: Millions of children worldwide are affected by poor linear growth, a result of inadequate nutrition and repeated infections during the first two years of life. Stunting prevalence varies between countries but is highest in low-income regions.

Aim: To study the association of faecal pH with childhood stunting.

Methods: A profile of 100 patients were included in this Prospective observational study Conducted in the Postgraduate Department of Pediatrics, Children Hospital, Bemina, an associated hospital of Government Medical College, Srinagar which is a referral tertiary care hospital for the children of Kashmir Valley. The study was initiated after receiving ethical clearance from the Institutional Ethical Committee and patients were recruited after obtaining the proper informed consent in the local language from the guardians. The weight, length, and height of the child were measured using standard protocol. Data regarding socioeconomic status, morbidity, dietary intake, and breastfeeding were collected using hard copy questionnaires at the time of enrolment and prior to sample collection. Chi square test was used to find the association between categorical variables (like LAZ and Faecal pH). $P<0.05$ was considered statistically significant.

Results: Significant association between fecal pH and childhood stunting ($p < 0.001$) was found among the study population. Children with severe stunting predominantly had a fecal pH above 6.5, indicating a higher prevalence of this condition in those with elevated pH levels. For moderate stunting, there was a clear distinction in pH values, with more children having a pH above 6.5 compared to those below. In mild stunting cases, most children had a fecal pH below 6.5. This suggests that fecal pH may be a relevant factor in assessing the severity of stunting in children.

Conclusion: In conclusion, our study provides evidence of a significant association between faecal pH and childhood stunting, highlighting a concerning trend of elevated faecal pH levels correlating with poorer nutritional outcomes in children.

Keywords: Stunting, faecal pH, childhood, poor nutritional, prevalence

Introduction:

Stunting affects more than one in every fifth child under five years, hindering the developmental potential of millions globally. [1] The factors contributing to stunting are numerous and complex.

Among the most well-known are low socioeconomic status [2] , infections, and inadequate diet. [3] However, high quality nutrition interventions have had little effect on growth. [4] Indeed, there is an interplay between contributing factors that are less well understood and has led to a new body of research exploring the role of environmental enteric dysfunction (EED) in childhood stunting.
Globally, stunting is the most prevalent form of malnutrition, estimated to affect 149 million children (22%) under five years. [5] Stunting has become a global health priority and in the last decade some countries have made progress in reducing the burden. [6,7]

Studies have shown a linkage between gut microbiota dysbiosis and intestinal inflammation caused by environmental enteric dysfunction (EED). [8,9] EED is a clinical condition marked by subclinical inflammation in the small intestine, blunting of the villi, and a decrease in the capacity of the intestines to absorb food. This condition is frequently found among individuals chronically exposed to enteropathogens due to residing in a contaminated environment with improper water, sanitation, and hygiene (WASH) conditions. [10] The Malnutrition and Enteric Disease (MAL-ED) study showed a high prevalence of EED among children in low and middle-income countries (LMICs). [11]

Studies have demonstrated that a simple technique like faecal pH estimation can give us a good surrogate estimation of the overall gut environment. [12,13] According to studies, variations in faecal pH can be linked to a variety of disease states, and extreme deviation from the normal range is associated with increased morbidity and mortality. [14-17] Therefore, measuring faecal pH can be a simple and cost-effective way to monitor gut health and potentially identify individuals at risk for certain diseases. However, further research is needed to determine the optimal range of faecal pH values for maintaining overall health and preventing diseases. A low-cost, ready-to-use technique to identify many intestinal illnesses is faecal pH.

This study, being the first of its kind in Kashmir, aims to fill a crucial gap in the existing literature. By exploring the association between faecal pH and childhood stunting, the research could offer new insights into the nutritional and metabolic factors influencing growth in this population. The findings could lead to more effective strategies for addressing stunting and improving child health outcomes in Kashmir and similar settings.

Material and Methods:
This Prospective observational **Study was conducted in the** Postgraduate Department of Pediatrics, Children Hospital, Bemina, an associated hospital of Government Medical College, Srinagar which is a referral tertiary care hospital for the children of Kashmir Valley over a period of 18 months.

Sample Size and Sampling
A sample size of 100 was determined using convenience sampling method. To achieve this sample size, patients admitted to the wards were listed on their second day of admission. Each week, on a designated day, 2 participants were chosen by lottery method from the list of patients in the sampling frame until the target sample size was achieved.

Inclusion Criteria
- Children aged < 5 years with length/height- for- age Z score less than -1 who were admitted to this hospital.

- **Exclusion Criteria**
- Patients with neurological disorders.
- Patients who refused to consent to the study.
- Patients admitted in ICUs.

- Patients on chemotherapy.

The study was initiated after receiving ethical clearance from the Institutional Ethical Committee and patients were recruited after obtaining the proper informed consent from the guardians.

METHODOLOGY

The weight, length, and height of the child were measured using standard protocol. Data regarding socioeconomic status, morbidity, dietary intake, and breastfeeding were collected using hard copy questionnaires at the time of enrolment and prior to sample collection.

Prior to the nutritional intervention, faecal samples of the children were collected. Following standard operating procedures, fresh non diarrheal faecal samples were collected immediately after defecation into a plastic pot and 1–2 g from that stool sample was relocated in a sterile specimen container. Ten milliliters of deionised water was mixed and homogenised with this stool properly. The probes of the pH meter were completely dipped into this mixture and kept for one minute and the reading was recorded. The procedure was done within the first 2 hours of sample collection. The test was carried out using the portable digital stool pH meter.

STATISTICAL ANALYSIS

Data was entered in a Microsoft Excel spreadsheet 2010. Continuous variables were summarized as a mean and standard deviation. Categorical variables were summarized as percentages. LAZ was calculated using WHO Anthroplus. Chi square test was used to find the association between categorical variables (like LAZ and Faecal pH). $P<0.05$ was considered statistically significant. Two sided p value was reported. Data analysis was performed using Stata version 15.

Results:

Among the total 100 children included in this study, Equal number of males (50%) and females (50%) constituted the study population. The most commonly affected age group in our study was 26-30 months, 65% followed by upto 25 months in 27% while the rest 8% belonged to the>30 months age group [Table 1].

Table 1: Demographic characteristics

Age (months)	%
Up to 25	27.0
26-30	65.0
>30	8.0
Male / Female	50/50

Regarding growth measurements, 54% of children had a length/ height-for-age Z score below -3 SD, 56% had a weight-for-age Z score below -3 SD [Table 2].

Table 2: Distribution of patients as per length/ height- for- age Z Score

Length/height- for- age Z Score	%
<-3 SD	54.0
B/W -3 SD to -2 SD	20.0
B/W -2 SD to -1 SD	26.0

Out of the mothers surveyed, 42% did not wash their hands before cooking, while 58% did. 82% of mothers washed their hands after assisting their child with defecation, whereas 18% did not perform hand hygiene following their child's defecation [Table 3].

Table 3: Mothers' Hand Washing Practice

Mothers' Hand Washing Practice		**%**
Before Cooking	**Yes**	**42.0**
	No	**58.0**
After helping the child to Defecate	**Yes**	**18.0**
	No	**82.0**

26% of patients had a history of antibiotic use, while 74% had not taken any antibiotics in the past 15 days. We found that 67% of the children were exclusively breastfed for the first six months, whereas 33% were given formula feeds along with breastfeeding. Additionally, 73% of the children in our study were non-vegetarian, in contrast to 27% who were vegetarian.

Table 4: Antibiotics Use, Breastfeeding Practice, Food Choice

Variables		**%**
Antibiotics use in the last 15 days	**Yes**	**74.0**
	No	**26.0**
Exclusive breastfeeding for the first six months	**Yes**	**33.0**
	No	**67.0**
Vegetarian	**Yes**	**73.0**
	No	**27.0**

A statistically significant association was found between faecal pH and childhood stunting ($p < 0.001$). Among children with severe stunting (length/height-for-age Z score < -3 S.D.), 9 had a faecal pH below 6.5, while 48 had a faecal pH above 6.5. For moderate stunting (length/height-for-age Z score between -3 S.D. and -2 S.D.), 6 children had a faecal pH below 6.5 compared to 12 with a faecal pH above 6.5. In cases of mild stunting (length/height-for-age Z score between -2 S.D. and -1 S.D.), 21 children had a faecal pH below 6.5, whereas 4 had a faecal pH above 6.5 [Fig 1a,b].

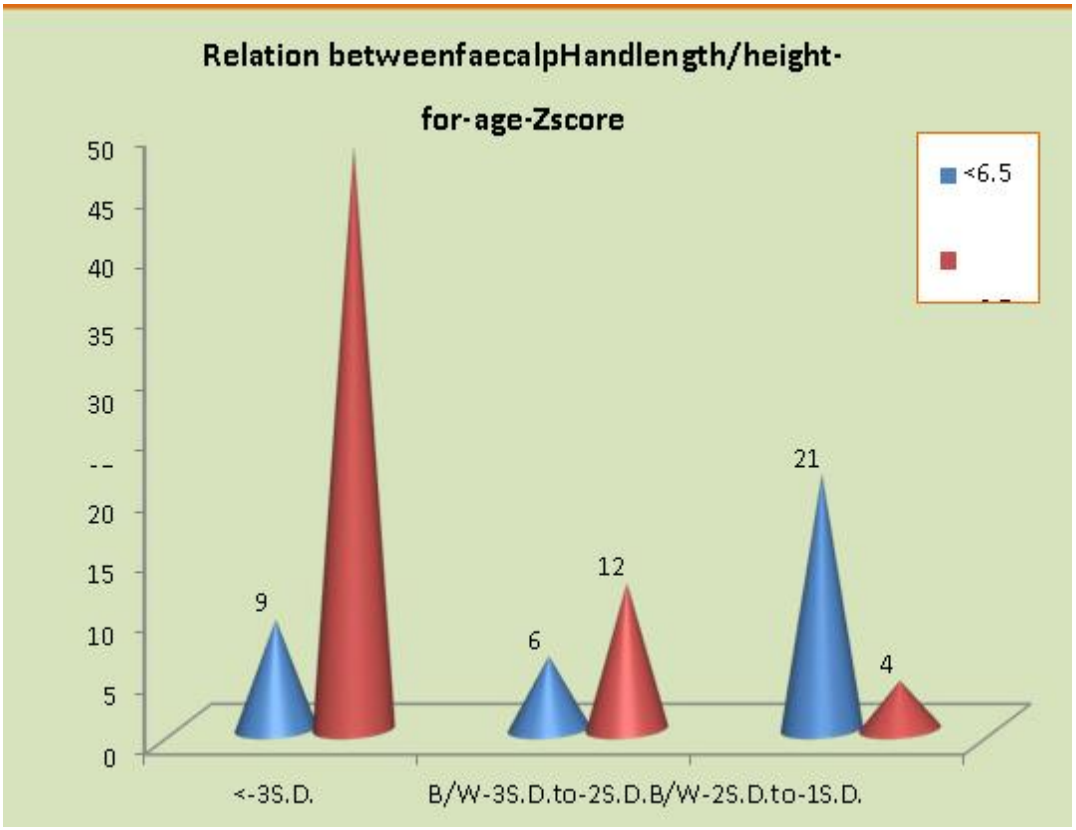

Fig 1 a.

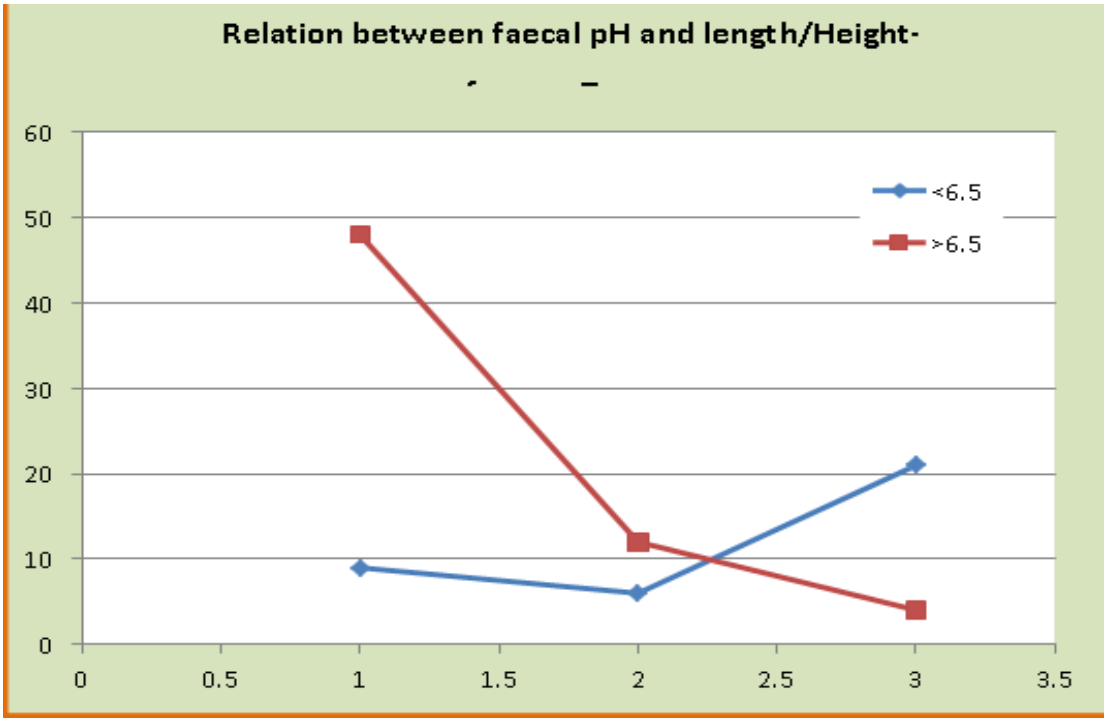

Fig 1 b.

Discussion:

A trend of increasing infant faecal pH has been observed over the past century, which demonstrated a change in faecal pH from 5.0 to 6.5 from 1926 to 2017. [18] This elevation of faecal pH is consistent with the reported reduction of certain important gut microflora. The factors responsible for the reduction of these important microbiota from the infant's gut over the past century comprise an increase in consumption of human milk replacers (e.g., infant formula), which lack the bacterial selectivity of human milk, [18] increased caesarean section delivery that limits the natural faecal-oral

transfer from mother to infant associated with vaginal delivery [19] and overuse of antibiotics which alter the acquisition of gut microbes by the infant. [20]
In our study, the most commonly affected age group was 26-30 months, 65% followed by upto 25 months, 27% while the rest 8% belonged to the >30 months age group. The youngest child being 23 months and the oldest 49 months of age. An equal number of males (50%) and females (50%) constituted the study population. Similar observations were demonstrated by **Siddiqa M et al., (2023). [21]**

In our study, length/height- for- age Z score was <-3 SD in 54%, B/W -3 to -2 SD in 20%, B/W -2 SD to -1 SD in 26%. Weight-for- age Zscore was <-3 SD in 56%, B/W -2 SD to -1 SD in 26%, and B/W -3 to <-2 SD in 18%. In a study conducted by **Siddiqa M et al., (2023)** , [21] three response variables of this study were the nutritional status of children, which was intended from weight- for-age z score (WAZ), height- for age z score (HAZ), and weight- for- height z score (WHZ), considering moderately (−3 to −2 of z-score) to severely malnourished (<−3 of z-score); whereas, a child having greater than −2 of z-score reflected a normal nutritional status. **Hossain MS et al., (2019)** did a study in which the mean LAZ and faecal pH of the children were −2.12±0.80 and 5.84±1.11, respectively. [22] Pearson correlation between faecal pH and LAZ scores showed a statistically significant negative correlation (−0.46, $p<0.01$).
The most common mother's age group was 26-30 years , 65%, upto 25 years, 27% and >30 years, 8%. In our study, 29% of mothers were working while 71% of mothers were not working. The majority of fathers of the study children were labourers (38%), 22% were shopkeepers, 16% were farmers, 17% were drivers and 7% were unemployed. **Tiwari R et al., (2014) [23]** did a study in which children in the age group 0–23 months born to younger mothers (aged <20 years) were less likely to be stunted compared with those born to older mothers (aged >20 years).
Mother's age in their study was 25-34 years (46.3%), 15-24 years (41.9%) and 35- 49 years (11.8%). These results were consistent with a study conducted in Iran **(Esfarjani F et al., 2013)**. [24] However, in the Iran study, it was found that children born to mothers older than 35 years of age were more likely to be stunted and severely stunted. On the contrary, a study in Mexico **(Varela-Silva MI et al., 2009) [25]** found that maternal age at child's birth was not a predictor for stunting. There were 43.4% working mothers and 56.6% non-working mothers which is consistent with our study finding. 70.6% of fathers were non-agricultural workers, 24.9% were agriculture workers and the rest 4.5% of fathers were not working.
In our study, 58% of mothers followed handwashing practice before cooking and 42% mothers did not follow handwashing practice before cooking meals.82% mothers followed handwashing practice after helping their child to defecate whereas 18 % of mothers did not follow handwashing practice after helping their child to defecate. Similar results were also observed by **Kwami CS et al., (2019) [26]**, in their study 99% of mothers and 59% of children used to wash their hands before eating. After defecation, 65% of children used to wash their hands, and 86% of mothers used to wash their hands after defecation. Community-level factors such as improved water, hygiene, and sanitation are also significant determinants of stunting **(Tariq J et al., 2018; Mahmood T et al., 2020)** . [27,28]

In our study, a history of antibiotic use was observed in 26% of patients, all 67% of children were exclusively breastfed for the first six months of life while 33% of children were breastfed as well as formula fed . In our study, 73% of children were non vegetarians while 27% of children were vegetarians. 64% of children were formula fed while 36% children did not consume formula feeds. A similar history of Antibiotic use (in the last 14 days) was reported by **Hossain MS et al., (2019)44** . [22]
In our study, 48% of children with Length/height–for-age Z score <-3SD had faecal pH >6.5 and 9% children had faecal pH <6.5. 12% of children with Length/height-for-age Z score between -3 SD and -2SD had faecal pH >6.5 while 6% of children had faecal pH <6.5. 4% of children with Length/ height –for-age Z score between -2SD and -1SD had faecal pH >6.5 while 21% of children had faecal pH < 6.5. **Hossain MS et al., (2019) [22]** did a study in which the mean LAZ and faecal pH of the

children were −2.12±0.80 and 5.84±1.11, respectively. Pearson correlation between faecal pH and LAZ scores showed a statistically significant negative correlation (−0.46, $p<0.01$) and showed a similar correlation between stool pH and the LAZ scores as well. A statistically significant inverse association was observed between faecal pH and with LAZ score of the children. **Dangour A et al., (2013) [29]** did a meta-analysis of 5 cluster randomized controlled trials that assessed interventions in water and hygiene (but not sanitation) and found a small but significant impact on HAZ ($P <0.05$; mean difference, 0.08; 95% confidence interval [CI], 0.00–0.16). **Gizaw Z et al., (2022) [30]** reported a significant association of stunting in children with poor dietary intake, poor hygiene, and sanitation conditions. **Siddiqa M et al., (2023) [21]** showed that the age of a child is positively associated with stunting. Children aged 13–24 months, 25–36 months, 37–48, and 49–60 months are more likely to be stunted as compared to children aged 0–6 months.

Conclusion:

In conclusion, our study provides evidence of a significant association between faecal pH and childhood stunting, highlighting a concerning trend of elevated faecal pH levels correlating with poorer nutritional outcomes in children. This association underscores the potential role of gut microbiota alterations due to factors such as increased use of infant formula, caesarean section delivery, and antibiotic overuse over the past century. These findings contribute to the growing body of literature linking gut health to childhood growth and development, emphasizing the need for interventions aimed at preserving and restoring healthy gut microbiota early in life. Future research should focus on longitudinal studies to elucidate causal relationships and explore targeted interventions to mitigate the impact of elevated faecal pH on childhood stunting.

Conflict of interest: Nil
Funding: Nil

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