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ORIGINAL ARTICLE

Age at First Solid Food Introduction and Its Association with Nutritional Status in Children: Evidence from Umerkot, Pakistan

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Abstract

Background

Malnutrition is a major contributor to child morbidity and mortality worldwide. While early life feeding practices, including timing of solid food introduction, are crucial determinants of nutritional status, evidence from rural Pakistan is limited.

Methods

A cross-sectional analytical study was conducted among 298 children aged 6–60 months admitted at District Headquarter Hospital, Umerkot. Data on age at first solid food introduction, dietary diversity, and anthropometry (MUAC) were collected. Nutritional status was assessed as per WHO criteria. Statistical analyses included chi-square tests, t-tests, ANOVA, logistic regression, and multivariate models to explore associations, adjusting for confounders like maternal education and rural residence.

Results

Mean age at first solid food introduction was 7.2 ± 2.1 months. Children introduced to solids before 6 months had higher odds of acute malnutrition (AOR: 2.5, 95% CI: 1.4–4.6, p<0.01). Delayed introduction (>8 months) was also associated with increased undernutrition risk (AOR: 1.9, 95% CI: 1.1–3.2). Appropriate timing (6–8 months) was linked to better nutritional outcomes. Early or delayed introduction also correlated with lower dietary diversity and higher micronutrient deficiencies.

Conclusions

Both early and late introduction of solid foods are significantly associated with malnutrition in hospitalized children. Education on timely complementary feeding and dietary diversity could mitigate these risks.

Keywords
Malnutrition; Solid food introduction; Dietary diversity; Pediatrics; Pakistan; Nutritional status

Abstracts in عربی، اردو, 中国人, русский, française and español at the end of the article

Layman Summary

Child malnutrition is a major problem in Pakistan, especially in rural areas like Umerkot. This study explored when children start eating solid foods and how it affects their health. We found that starting solid foods too early (before 6 months) or too late (after 8 months) increases the risk of poor growth and weak nutrition. Children introduced to solids at the right age (6–8 months) had better health and nutrition. The study suggests that families should start giving solid foods at around 6 months and include a variety of foods like vegetables, fruits, and meat to help children grow strong and healthy. Educating mothers and communities about this can reduce child malnutrition.

INTRODUCTION

Malnutrition remains one of the most pressing global public health challenges, contributing to nearly 45% of deaths among children under five years of age worldwide [1, 2]. It not only compromises physical growth but also impairs cognitive development, weakens immunity, and increases susceptibility to infections, ultimately undermining the potential of entire generations. In Pakistan, the situation is particularly dire: the National Nutrition Survey 2018 reported that 40% of children under five are stunted, 17.7% are wasted, and 28.9% are underweight [3, 4]. These alarming statistics underscore a profound nutritional crisis that poses a significant threat to child health, survival, and long-term societal development.

Child nutrition is a complex outcome shaped by a web of interrelated factors. Socioeconomic disparities, maternal education [5], cultural beliefs [6], food insecurity [7], and recurrent infections [5] all contribute to poor nutritional outcomes. Among these, infant and young child feeding practices, especially the timing of introducing complementary foods, play a central role. According to the World Health Organization (WHO), exclusive breastfeeding is recommended for the first six months of life, followed by the introduction of appropriate complementary foods while continuing breastfeeding. Introducing solid foods before six months may displace essential breast milk nutrients and increase the risk of infections due to immature gut barriers [8]. Conversely, delaying the introduction of solids beyond eight months can lead to insufficient energy and micronutrient intake during a critical growth period, potentially resulting in faltered growth and increased vulnerability to disease [9, 10].

The timing of solid food introduction is not merely a nutritional decision; it is profoundly shaped by cultural norms, caregiver knowledge, and access to health services [8, 11]. In rural and resource-limited settings of Pakistan, like Umerkot, these challenges are even more pronounced. Umerkot, located in the southeastern province of Sindh, faces high rates of poverty, food insecurity, and limited healthcare access, creating a precarious environment for optimal child feeding practices. Studies from this region have documented strong links between monotonous cereal-based diets, low dietary diversity, and widespread micronutrient deficiencies, particularly deficiencies in iron, vitamin A, and zinc [12, 13]. These deficiencies further exacerbate the cycle of malnutrition, impair immune function, and hinder recovery from common childhood illnesses.

Despite growing evidence on the importance of dietary diversity and appropriate feeding practices, there remains a striking lack of data specifically examining how the age at first solid food introduction influences nutritional status in this vulnerable population. Existing research in Umerkot has largely focused on broad associations between dietary patterns and general nutritional outcomes, without delving into the critical window when complementary feeding begins [14, 15]. Understanding this relationship is crucial, as it may help identify modifiable practices that can be targeted through community-level interventions, caregiver education, and health system strengthening efforts.

This study seeks to fill this knowledge gap by exploring the association between the age at which solid foods are introduced and the current nutritional status of children hospitalized in Umerkot. By leveraging detailed clinical and dietary data from a cohort of children under five years of age, this research aims to provide evidence-based insights that can inform public health strategies tailored to rural Pakistani contexts. Specifically, the study examines whether early (<6 months), timely (6–8 months), or delayed (>8 months) introduction of solid foods is linked to malnutrition and micronutrient deficiencies.

The findings are expected to contribute to the refinement of national and local child nutrition policies, support culturally appropriate health promotion campaigns, and guide healthcare providers in delivering targeted counseling to caregivers. Ultimately, addressing inappropriate complementary feeding practices holds the promise of improving child growth and development outcomes, reducing hospitalizations, and moving closer to achieving global and national nutrition targets.

MATERIALS AND METHODS

Study design and setting

A hospital-based cross-sectional analytical study was conducted at the District Headquarter (DHQ) Hospital in Umerkot, Sindh, Pakistan. This 200-bed secondary healthcare facility serves an estimated population of approximately 1.2 million individuals residing in both urban and predominantly rural areas. The hospital functions as a referral center for nearby primary health centers and basic health units, providing essential inpatient and outpatient services, including pediatric care. The study was carried out over a one-month period in March 2022, coinciding with seasonal peaks in pediatric admissions related to infectious diseases.

Study population

The study population consisted of children aged between 6 months and 5 years admitted to the male and female pediatric wards during the study period. Inclusion criteria were: (i) children within the specified age range, (ii) availability of complete data on feeding practices, including the precise age at first solid food introduction, and (iii) documented anthropometric measurements at admission. Children with chronic medical conditions (e.g., congenital heart disease, metabolic disorders), known genetic syndromes, or incomplete medical records were excluded to minimize potential confounding factors related to growth and nutrition.

Sampling technique

A non-probability sequential (consecutive) sampling method was employed. All eligible children admitted during the study period who met inclusion criteria and whose caregivers provided informed consent were enrolled until the target sample size was achieved. This approach ensured maximal capture of available cases during the study window and reduced potential selection bias.

Objectives of the research

- Primary objective: To determine the association between the age at first solid food introduction and the current nutritional status of hospitalized children, categorized as normal, moderately acutely malnourished, or severely malnourished based on WHO standards.
- Secondary objectives: To assess the relationship between feeding practices and dietary diversity, and to explore associations with specific micronutrient deficiencies (iron, vitamin A, zinc).

Biases and confounders

To mitigate selection bias, all consecutively admitted eligible children during the defined period were included. Recall bias regarding feeding practices was minimized by using a standardized, pretested structured questionnaire administered by trained data collectors who assisted caregivers in recalling feeding milestones through calendar landmark events (e.g., religious holidays, family events). Potential confounders such as maternal education level, residential status (urban vs. rural), socio-economic status, and immunization completeness were identified a priori and adjusted for in multivariate regression models to isolate the effect of age at solid food introduction on nutritional outcomes. Measurement bias was addressed through rigorous training and standardization of anthropometric assessment.

Data collection

Data were collected using a comprehensive structured questionnaire, developed in English and translated into Sindhi and Urdu for local comprehension. The questionnaire captured detailed socio-demographic information (e.g., child's age and sex, parental education, household income, residence), feeding practices (age at first solid food introduction, breastfeeding duration, frequency and

diversity of complementary foods), and illness history (recent infections, hospitalizations).

Anthropometric assessments included weight (measured to the nearest 0.1 kg using calibrated digital pediatric scales), height or length (to the nearest 0.1 cm using standard stadiometers or length boards), and mid-upper arm circumference (MUAC) measured at the mid-point between the acromion and olecranon processes on the left arm using non-stretchable MUAC tapes. Nutritional status was classified following WHO growth standards, with MUAC thresholds for moderate acute malnutrition (MAM: 115–124 mm) and severe acute malnutrition (SAM: <115 mm).

Where feasible, blood samples were collected and analyzed for micronutrient levels (hemoglobin, serum retinol, and serum zinc) using standard laboratory methods to document deficiencies.

Quality control measures

All data collectors (medical officers and nursing staff) underwent intensive training workshops on interviewing techniques, anthropometric measurement, and standardized data entry procedures. Daily calibration of measurement tools (weighing scales, stadiometers, MUAC tapes) was performed to ensure accuracy. Field supervisors reviewed completed forms daily for completeness and consistency. Double data entry was conducted in EpiData, with cross-verification against original forms to minimize transcription errors. Discrepancies were resolved through review meetings involving field staff and principal investigators.

Sample size estimation

Based on prior regional studies indicating a 15% prevalence of malnutrition among hospitalized children, the sample size was calculated using the formula for cross-sectional studies:

$$n = Z^2 * p(1-p) / d^2,$$

where Z = 1.96 for a 95% confidence interval, p = 0.15 (prevalence of wasting)[16], *and d = 0.05 (margin of error).*

The estimated minimum sample size was 194 children. Considering feasibility and potential non-responses, we targeted at least 300 children. Ultimately, 298 children with complete data were included in the final analysis, representing a 98% completion rate and sufficient power for multivariate analyses.

Data analysis

Data were analyzed using SPSS version 22.0. Continuous variables (e.g., age, anthropometric measures) were summarized using means and standard deviations, while categorical variables (e.g., sex, feeding categories) were presented as frequencies and percentages. Associations between categorical variables were assessed using chi-square or Fisher's exact tests as appropriate. For continuous variable comparisons across feeding groups, independent t-tests or one-way ANOVA with post hoc Bonferroni corrections were applied.

Pearson's correlation coefficient was used to examine relationships between continuous feeding variables and nutritional indicators. Logistic regression analyses were conducted to calculate crude and adjusted odds ratios (ORs) with 95% confidence intervals, adjusting for confounders such as maternal education, residence, child age, child gender, household wealth-index and immunization status. Multivariate analyses included hierarchical logistic regression to evaluate the independent effect of feeding practices on malnutrition severity and micronutrient deficiencies. Statistical significance was defined as a two-sided p-value < 0.05.

Ethical considerations

Ethical approval was obtained from the Institutional Review Board (IRB) of Shaheed Zulfikar Ali Bhutto Institute of Science and Technology (SZABIST) University. Informed written consent was obtained from parents or guardians before enrollment. All participants were assured of confidentiality, anonymity, and the voluntary nature of participation, with the right to withdraw at any stage without any effect on their medical care. Data were stored securely, and only aggregated findings are reported.

RESULTS

Characteristics of the participants

A total of 298 children aged 6 months to 5 years were included in the final analysis. The mean age of participants was 19.4 ± 15.2 months, with a majority (61.7%, n = 184) being male and the remaining 38.3% (n = 114) female. In terms of residence, 66.1% (n = 197) of the children were from rural areas, while 33.9% (n = 101) were from urban settings. The mean age at first solid food introduction across the cohort was 7.2 ± 2.1 months. Detailed sociodemographic characteristics are presented in Table 1.

Table 1. Sociodemographic characteristics

Variable	N (%)
Male	184 (61.7)
Female	114 (38.3)
Rural residence	197 (66.1)
Urban residence	101 (33.9)

Main findings

Feeding practices and malnutrition prevalence

Analysis of feeding practices revealed that 23% (n = 69) of the children were introduced to solid foods before 6 months (early introduction), 56% (n = 167) had timely introduction between 6 and 8 months, and 21% (n = 62) experienced delayed introduction after 8 months.

The prevalence of malnutrition was significantly higher in children with early (49%) and delayed (42%) solid food introduction compared to those with timely introduction (27%) (p < 0.001). These findings indicate a strong association between inappropriate timing of complementary feeding and nutritional status. Detailed distribution is presented in Table 2.

Risk analysis of malnutrition

Multivariate logistic regression analysis, adjusted for confounders such as maternal education, residence, and immunization status, demonstrated that early introduction of solid foods significantly increased the risk of malnutrition (adjusted odds ratio [AOR]: 2.5; 95% confidence interval [CI]: 1.4–4.6; p < 0.01). Similarly, delayed introduction also showed an elevated risk of malnutrition (AOR: 1.9; 95% CI: 1.1–3.2; p = 0.02). These results underscore the critical importance of the appropriate timing of complementary feeding in preventing malnutrition (see Table 3).

Table 3. Multivariate logistic regression for malnutrition risk

Variable	AOR	95% CI	p-value
Early introduction	2.5	1.4–4.6	<0.01
Delayed introduction	1.9	1.1–3.2	0.02

Micronutrient deficiencies and feeding practices

The study also explored the relationship between feeding practices and micronutrient deficiencies. Iron deficiency was observed in 45% of children with early introduction and 41% in those with delayed introduction, compared to 30% among those with timely introduction. Similarly, vitamin A deficiency was prevalent in 38% and 35% of early and delayed introduction groups, respectively, compared to 22% among children with timely introduction. Zinc deficiency followed a similar trend, affecting 42% and 39% of children with early and delayed introduction, respectively, versus 25% among those introduced to solids at the recommended age (p < 0.001 for all comparisons). These findings highlight the role of appropriate complementary feeding in reducing micronutrient deficiencies and are detailed in Table 4.

Table 4. Micronutrient deficiencies by age at solid food introduction

Deficiency	Early (%)	Timely (%)	Delayed (%)
Iron deficiency	45%	30%	41%
Vitamin A deficiency	38%	22%	35%
Zinc deficiency	42%	25%	39%

DISCUSSION

The present study explored the association between the timing of solid food introduction and nutritional outcomes among young children in rural Pakistan, highlighting that early (<6 months) and delayed (>8 months) introduction of complementary foods are linked to higher rates of malnutrition and micronutrient deficiencies. These findings align with global evidence emphasizing the critical window for introducing complementary foods at six months of age [20].

The observed high prevalence of malnutrition in children introduced to solids either too early or too late mirrors trends seen in rural Sindh, where stunting affects approximately 50% and wasting 15% of children under five [16]. These rates emphasize how deviations from recommended feeding timelines can severely compromise growth trajectories, as also underscored by Headey et al. (2016)[19], who identified inappropriate complementary feeding as a key barrier to improving child growth outcomes in South Asia.

Our findings are consistent with the longitudinal observations by Mughis et al. (2025)[17], who reported that infants in rural Pakistan introduced to complementary feeding before four months had a significantly higher risk of wasting by six months of age. Similarly, delayed introduction of complementary foods can create nutrient deficits during a critical period for growth, as noted in South African community-based intervention studies, where education on timely complementary feeding significantly improved weight and length gains [20].

Dietary diversity also emerged as a crucial factor in our study, with children receiving monotonous cereal-based diets more likely to show signs of micronutrient deficiencies. This observation aligns with the findings from Gazipur, Bangladesh, where despite high rates of timely introduction, complementary diets often lacked diversity, contributing to undernutrition[22]. Similar conclusions were drawn in a Tanzanian cohort, where low dietary diversity was associated with increased risks of stunting and underweight [23].

Furthermore, the study by Boateng et al. (2019)[21] in Ghana demonstrated that the nutritional quality of complementary foods—such as those fortified with Moringa oleifera—significantly affects hemoglobin levels and growth outcomes. Although our setting lacked food fortification, the role of dietary quality parallels our findings, emphasizing the importance of micronutrient-rich complementary foods.

Socioeconomic factors, including maternal education and household wealth, played a significant role in the nutritional outcomes observed in our cohort. Headey et al. (2016)[19] highlighted that improvements in female education and household assets were strongly associated with reductions in child undernutrition across South Asia. In our study, children from lower socioeconomic backgrounds were more prone to inappropriate feeding practices and resulting malnutrition.

Developmental delays are another consequence of poor nutritional practices. Saleem et al. (2021)[18] reported that children with severe acute malnutrition in rural Pakistan had higher risks of global developmental delays, especially among those who were not exclusively breastfed or who had early introduction of solids. This reinforces our findings regarding the long-term implications of suboptimal feeding practices beyond immediate physical growth.

Additionally, the evaluation of complementary feeding indicators using the Infant and Young Child Feeding Index (IYCFI) framework showed that higher dietary diversity and minimum meal frequency are crucial for optimal growth outcomes [24]. While our study did not use IYCFI scoring explicitly, the trends observed echo these conclusions, underlining the value of comprehensive feeding assessments.

The importance of culturally sensitive community-based interventions is supported by multiple studies. For instance, the community-driven education model in South Africa [20] and regional analyses in Ghana [7] and Pakistan [17] suggest that promoting caregiver knowledge and behavior change is pivotal in achieving sustainable nutritional improvements.

In summary, our findings underscore the critical importance of introducing complementary foods at 6–8 months, ensuring dietary diversity, and integrating caregiver education to combat malnutrition and promote healthy development. The comparison with regional and global evidence further supports the urgent need for tailored, culturally appropriate nutrition strategies in rural Pakistan.

Study strengths and limitations

One major strength of this study is its rigorous methodological approach. The use of standardized WHO protocols for anthropometric assessments and thorough adjustment for potential confounders such as maternal education, residential status, and immunization completeness lends robustness to our findings. The sample size was sufficiently large, enhancing the study's power to detect meaningful associations. Moreover, inclusion of micronutrient deficiency data alongside anthropometric indicators provides a comprehensive view of child nutritional status.

However, there are important limitations to acknowledge. The cross-sectional design restricts the ability to infer causality; while associations can be identified, temporal relationships cannot be conclusively established. Furthermore, the study's hospital-based setting may introduce selection bias, potentially overrepresenting more severely ill and malnourished children compared to the general community population. This could limit the generalizability of findings to all children in Umerkot or similar settings. Additionally, data on feeding practices relied on caregiver recall, which may be subject to memory inaccuracies and social desirability bias, despite efforts to mitigate this through careful interviewing techniques and the use of landmark events to aid recall.

CONCLUSION AND RECOMMENDATIONS

Appropriate timing of solid food introduction, specifically between 6 and 8 months, is crucial and strongly associated with improved nutritional outcomes among children. Introducing solids either too early or too late significantly increases the risk of malnutrition and critical micronutrient deficiencies. Promoting timely, diverse complementary feeding practices through caregiver education and integrated community health programs is essential to improve child growth, reduce hospitalizations, and support overall child health in resource-limited settings.

Future research implications and policy considerations

Future research should focus on prospective longitudinal studies to better elucidate causal relationships between timing of complementary feeding and child nutritional outcomes. Such studies could follow children from birth to early childhood, monitoring feeding practices, infection episodes, dietary diversity, and growth trajectories over time. This would provide a more dynamic understanding of how early nutritional exposures impact long-term health.

From a policy perspective, these findings underscore the necessity of integrating infant and young child feeding counseling into existing maternal and child health services at both facility and community levels. Policymakers should prioritize the development and implementation of culturally appropriate behavior change communication strategies targeting misconceptions around feeding timelines. Strengthening training for frontline health workers to provide consistent, evidence-based counseling on complementary feeding could substantially improve adherence to WHO recommendations.

Moreover, nutrition-sensitive social protection programs, such as conditional cash transfers tied to child health check-ups and

nutritional counseling sessions, could incentivize timely and appropriate feeding practices among vulnerable populations. Agricultural and food system policies should also focus on improving access to diverse, affordable, and nutrient-rich foods to support caregivers in providing optimal diets for their children.

By aligning research, community interventions, and policy strategies, significant progress can be made toward reducing child malnutrition and achieving national and global nutrition targets, including Sustainable Development Goal 2 on ending hunger and all forms of malnutrition.

SUPPORTING INFORMATION

File 1: Questionnaire/tool on feeding practices and dietary diversity
File 2: Data collection forms
File 3: Ethical approval letter

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AUTHORS CONTRIBUTIONS

- Conceptualization: JMV, HSM
- Data Curation: JMV, HSM
- Formal Analysis: JMV, HSM
- Investigation: JMV, HSM
- Methodology: JMV, HSM
- Project Administration: JMV, HSM
- Resources: JMV, HSM
- Software: JMV, HSM
- Supervision: JMV, HSM
- Validation: JMV
- Visualization: JMV
- Writing – Original Draft Preparation: JMV

Writing – Review & Editing: HSM

What is already known about this topic

- Malnutrition is prevalent among under-five children in rural Pakistan.
- WHO recommends solid food introduction at 6 months.
- Improper feeding practices contribute to child undernutrition.
- Dietary diversity is essential for preventing micronutrient deficiencies.

What does this study adds to the current literature

- Evidence linking early and delayed solid food introduction with malnutrition in Pakistani hospitalized children.
- Highlights micronutrient deficiencies associated with feeding timing.
- Provides data supporting culturally sensitive complementary feeding programs.
- Suggests integrating feeding counseling in rural health strategies.

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