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Article

Association of Infant Feeding Indicators and Infant Feeding Practices with Coexisting Forms of Malnutrition in Children under Six Months of Age

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Abstract: Breastmilk is the only recommended source of nutrition for infants below six-months of age. However, a significant proportion of children are either on supplemental breastfeeding(SBF) or weaned due to the early introduction of solid/semi-solid/soft food and liquids(SSF) before 6 months of age. There is good evidence that Exclusive Breastfeeding(EBF) in infants below six-months of age protects them from preventable illnesses, including malnutrition. The relationship between infant feeding practices and coexisting forms of malnutrition(CFM) has not yet been explored. This study examined the association of different feeding indicators(continuation of breastfeeding, predominant feeding, and SSF) and feeding practices(EBF, SBF, and complete weaning) with CFM in infants aged below six-months of age in Pakistan. National and regional datasets of Pakistan from the last ten years were retrieved from the Demographic Health Surveys(DHS) and UNICEF data repositories. In Pakistan, 34.5%(n=6131) of infants have some form of malnutrition. Among malnourished infants, 44.7%(~15.4% of the total sample) had a CFM. Continuation of breastfeeding was observed in more than 85% of infants, but less than a quarter were on EBF, and the rest were either SBF(65.4%) or weaned infants(13.7%). Compared to EBF, complete weaning increased the odds of coexistence of underweight with wasting and underweight with both wasting and stunting by 1.96(1.12-3.47) and 2.25(1.16-4.36), respectively. Overall, breastfed children had lower odds of various forms of CFM (compared to non-breastfed), except for the coexistence of stunting with overweight/obesity. Continuation of any breastfeeding protects infants in Pakistan from various types of CFM during the first six months of life.

Keywords: Malnutrition; association; feeding; practice; infants; Pakistan

1. INTRODUCTION

1.1. Background:

Breastmilk is a natural source of nutrition for newborns and infants [1]. It contains all nutrients, which are essential for the growth and nourishment of a newborn and a growing infant, such as carbohydrates, proteins, fats, vitamins, and trace elements [2, 3]. Breastmilk is enriched with all five immunoglobulins (Ig), such as IgA, IgD, IgE, IgG, and IgM, that provide immunity against various infections and common preventable diseases, such as diarrhea, pneumonia, necrotizing enterocolitis, otitis media, neonatal septicemia, and various preventable

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illnesses [1-4]. Benefits of receiving breastmilk continue over the life course, protecting from several non-communicable and metabolic diseases in adulthood, including diabetes and obesity [5]. Breastfeeding also protects nursing mothers from breast cancer, ovarian cancer, coronary heart disease (CHD), diabetes, and unplanned pregnancies [1, 5]. The World Health Organization (WHO) and the American Academy of Pediatrics (AAP) recommend exclusive breastfeeding (EBF) for infants up to six months of age, and continued breastfeeding to two-years and beyond if the dyad can continue [6, 7].

Despite the universal recommendation and promising health outcomes associated with EBF, more than half of infants worldwide do not receive EBF for the first six-months of their life [8]. Supplemental Breastfeeding (SBF) and complete weaning are two alternative practices to EBF adopted by mothers and/or caregivers [6, 9, 10]. SBF refers to the use of either water, formula milk, cattle milk, and solid/semi-solid food together with breastmilk for feeding a neonate and infant below six months of age [6, 10], while complete weaning refers to feeding solid, semi-solid/soft, and liquid food after complete cessation of breastmilk before six-months of a child's life [11]. Both SBF and complete weaning practices are associated with various types of malnutrition, including coexisting forms of malnutrition (CFM) [9, 11, 12].

CFM represents the simultaneous occurrence of either two or more forms of nutritional disorders in an individual [13, 14] (e.g., an individual who is both stunted and overweight/obese or underweight with wasting and/or stunting and/or both). In general, women of reproductive age and children below five years of age are highly vulnerable to various forms of nutritional disorders, including CFM [15]. Worldwide, more than two-thirds of malnourished children aged below five-years reside in most of the South Asian and Sub-Saharan African countries [16, 17]. Among South Asian countries, Pakistan is the second largest South Asian country, where the burden of malnutrition has been stagnant for the last four decades [15, 16]. This stagnancy in the prevalence of pediatric malnutrition is associated with various preventable illnesses, including malnutrition, and malnutrition itself contributes to around half of deaths in children [18-20]. Previous studies have shown that an adherence to infant feeding effectively reduces the burden of neonatal and infant deaths owing to various preventable illnesses, including malnutrition by 20% [21, 22].

The evidence regarding the importance of breastmilk has been supported by various observational and experimental studies. Previous studies have provided good evidence for EBF and reduced risk of malnutrition in infants', but the relationship of EBF with various forms of CFM has not been explored. To the best of our knowledge, this is the first study to examine the relationship between different types of feeding indicators (Continuation of Breastfeeding (CBF), Predominant feeding (PF), Introduction of solid, semi-solid, soft & liquid food (SSF)) and feeding practices (EBF, SBF, and complete weaning practices) and various forms of CFM.

1.2. Conceptual framework:

The conceptual framework for assessing the relationship of infant feeding practices with their nutritional status is presented in Figure-1. At a microlevel, the nutritional status of a child is influenced by the child's own biology (e.g., child biological age, gestational age, gender, birth type,

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birthweight, congenital anomality, and post-natal health/disease status), maternal biology (e.g., maternal age, maternal health before conception, during pregnancy and after childbirth, weight gain during pregnancy, maternal co-morbidity, maternal micronutrient status, maternal complication during pregnancy and after childbirth, method of childbirth, child size, birth intervals), and interacting factors (e.g., maternal education, maternal employment status, feeding frequency, and feeding duration). However, at a macrolevel, several environmental, cultural, household, and psychological factors affect the feeding practices and nutritional status of a child (Figure-1).

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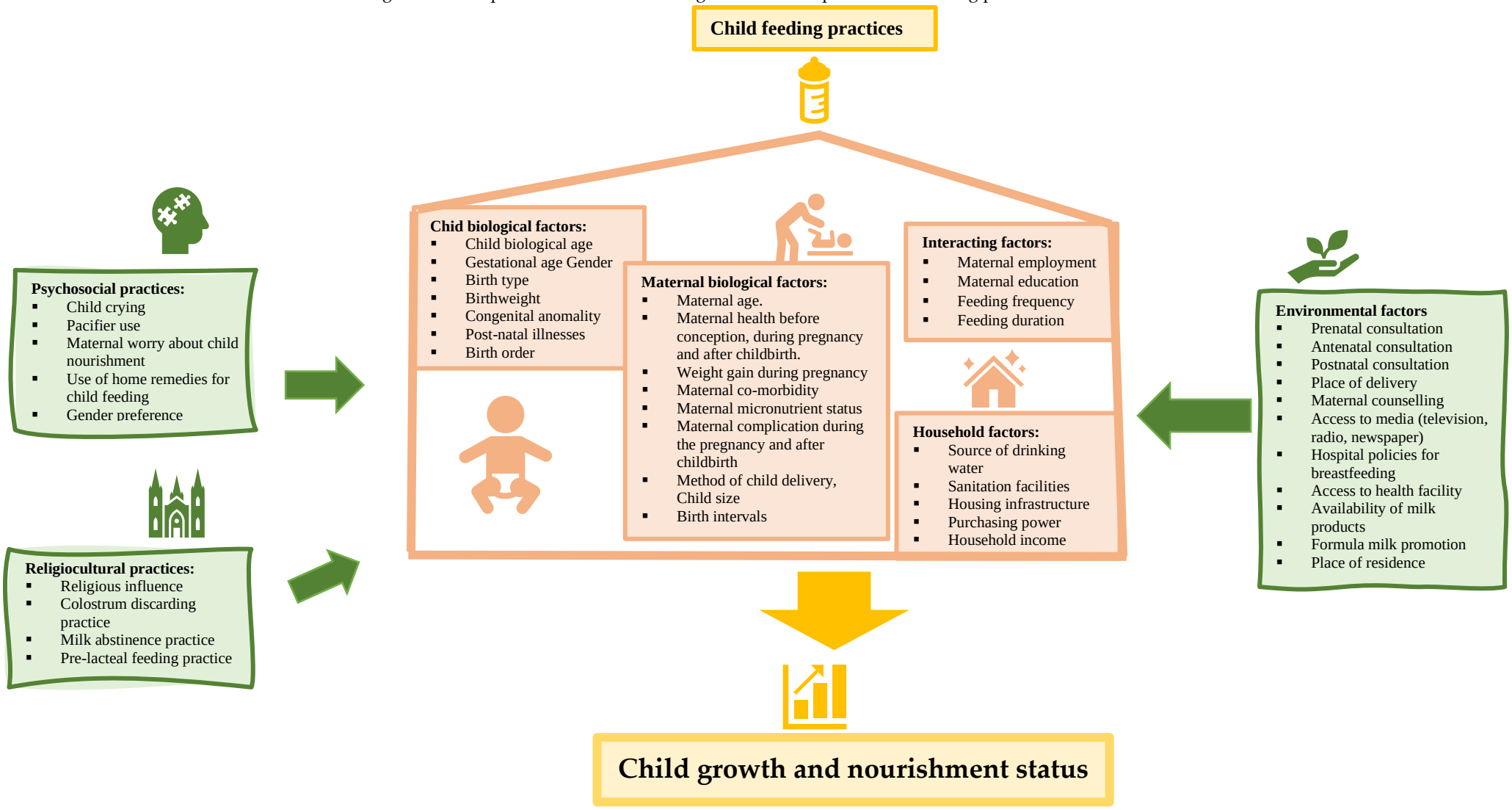
Figure-1: Conceptual framework indicating the relationship of infant's feeding practices with the nutritional status



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2. METHODOLOGY

2.1. Datasets

This is a secondary data analysis of Pakistan Demographic and Health Surveys (PDHS) and Multiple Indicator Cluster Surveys (MICS) datasets, which were retrieved from the DHS program and from UNICEF, respectively, after formal registration and approval. The PDHS collects information relating to demography and health indicators using different sets of questionnaires at the national level. The MICS collects health and demographic data from children and their mothers at the regional level [23-25]. In this study, a total of ten different datasets, two from the last two PDHS and eight from MICS, were merged for assessing the relationship between CFM with different feeding practices that may encountered in infants aged below six-months. Data from the PDHS-1990-1991, PDHS-2006-2007, and MICS-1995 were excluded because they did not include most of the feeding indicators related to Infants and Young Child Feeding Practices (IYCF) indicators.

2.2. Study population, sample size, and sampling method

The target population in each DHS and MICS survey was women of reproductive age, who were interviewed using a multistage stratified cluster sampling method. Further detail about the sampling method has been presented elsewhere [26]. From the main sample of the study, data of infants aged below 5.9 months were analysed, consistent with EBF guidelines proposed by Infants and Young Child Feeding (IYCF) [6]. Children were excluded if aged over 5.9 months, had missing anthropometry, or had anthropometric red flags (outliers). The World Health Organization (WHO) has described different ranges of anthropometric outliers for each anthropometric index. A cut-off value exceeding ±6.00 S.D. for HAZ/LAZ , ±5.00 S.D. for WHZ, and of -6.00 and +5.00 S.D. for WAZ was considered an outlier [27, 28]. After excluding data of all ineligible cases, we analysed data of 17,782 children **(Further detail – Supplementary file-1).**

2.3. Measurement of outcome variables

A series of steps were used for classifying the type of CFM. Firstly, data of all the children with a missing value for either age, and/or sex, and/or weight, and/or height/length and/or measurement position were removed. Second, the anthropometric data was imported into the WHO AnthroCal ® software for Z-score calculation. WHO AnthroCal calculates four anthropometric indices; Weight for Length/Height (WHZ), Weight for Age (WAZ), Length/Height for Age (HAZ), and Body Mass Index z-scores (BAZ) for assessing the nutritional status of a child. In this study, WHZ, WAZ and HAZ were considered for assessing various forms of malnutrition, while BAZ was excluded because it is a poor predictor for assessing nutritional status in young children [29, 30]. Thirdly, all anthropometric outliers (outlined in Section 2.2) were removed from the analysis files. Finally, nutritional status of each child across nine mutually exclusive categories was determined, of which four represented CFM (e.g., coexistence of: underweight with wasting; underweight with stunting; underweight with both wasting and stunting, and stunting with overweight/obesity), four represented standalone forms of malnutrition (e.g., wasting, stunting, underweight, and overweight/obesity), and one

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represented healthy nutritional status. Further details regarding the assessment of nutritional status in this research are reported elsewhere [26].

2.4. Measurement of independent variables

In each PDHS and MICS survey, data related to feeding practices were obtained from mothers using a food list proposed in the "*Infant & Young Child Feeding (IYCF)* guidelines by the World Health Organization (WHO) and UNICEF for children aged below two-years. Parents of children below two-years responded either yes or no against each food item consumed by their children in last twenty-four hours. The response to different food items were then used to derive a set of feeding indicators. The current IYCF guidelines of 2021 have set seventeen feeding indicators (15 indictors in 2010 IYCF guidelines) for improving the health & nourishment of children below two-years of age, some of which are age-specific [31, 32]. We examined the relationship of three infant feeding indicators with various forms of CFM: *Continuation of breastfeeding (BF), Predominant feeding (PF), and Solid, semi-solid & liquid feeding (SSF).* Continuation of BF can be defined as consumption of breastmilk by an infant in the last 24 hours. Any neonate & infant who consumed water, and/or juice, and/or clear broth, and/or clear tea without milk in addition to breastmilk were categorised as PF. Infants who consumed animal milk, and/or formula milk, and/or yogurt, and/or porridge, and/or tea with milk, and/or soft & semi-solid liquid & food were categorised as SSF.

The relationship of various forms of CFM with infant feeding practices was also investigated. Three different types of feeding practice (EBF, SBF, and complete weaning) were derived following IYCF guidelines using a number of questions related to feeding indicators [31, 32] (Supplementary file 2)

An **exclusive breastfed** child was one who consumed breastmilk either alone or together with ORS or/ Multivitamins/mineral a day before data collection.

A **supplementary breastfed** child was one who consumed solid food or semi-solid food or liquid diet or formula milk or predominant feeding together with breastfeeding. Based on the consumption of different types of foods and liquids, four different types of SBF practices were derived.: a) coadministration of breastmilk with infant formula, b) coadministration of breastmilk with animal milk, c) coadministration of breastmilk with water, juice, broth, and other liquid, and d) coadministration of breastmilk with solid, semi-solid, and soft food.

A **weaned** child was one who consumed solid food or semi-solid food or liquid diet or formula milk or predominant feeding either alone or in combination before 6 months of age in the absence of breastfeeding.

2.5. Covariates

Several covariates were identified that could potentially influence the relationship between feeding practices and nutritional status of infants under 6 months of age. We considered maternal, child, household, environmental, cultural, and psychosocial factors for assessing the relationship of infant feeding practices with their nutritional status. In

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this study, some covariates were not available in the DHS and MICS datasets. Covariates considered for the analysis included:

Child factors: biological age (0 to 1.9 months, 2 to 3.9 months, and 4 to 5.9 months), sex (male and female), and post-natal illnesses (Yes and No).

Maternal factors: maternal education, categorized as none, primary education, and secondary or higher education.

Household factors: socioeconomic status, which was pre-calculated in each dataset with five categories: poorest, poorer, middle, richer, and richest. Place of residence, in two categories: urban and rural

2.6. Data management and data analysis

Different statistical software (Microsoft Excel, SPSS and Jamovi) were used to analyse data. Before performing inferential statistics, four data files each representing a type of CFM with its corresponding reference category were created. The reference category for coexistence of underweight with wasting, stunting, and both was 'underweight', while the reference category for coexistence of stunting with overweight/obesity was stunting. Data from each new file was then used for inferential analysis.

In this study, the inferential analysis was performed at three levels. Firstly, the association of each feeding indicator: continuation of breastmilk, predominant feeding, and solid, semi-solid & soft food was measured with each form of CFM. Secondly, the association of each feeding practices, such as, EBF, SBF, and early weaning practices and CFM were examined. Lastly, association of each type of SBF was assessed with different forms of CFM. During the inferential analysis, at first, the unadjusted odds for each study outcome using binomial regression were calculated (Supplementary file 4). A 95% confidence interval was used to indicate the uncertainty of the estimates or results. In preliminary analysis, we did not find a high degree of collinearity between any covariates; thus, all covariates were considered for calculating the adjusted odds of each study outcome.

2.7. Ethical clearance

The data of this study was retrieved formally from the DHS and UNICEF data repositories. Ethical clearance was obtained from the University Human Research Ethics Committee (UHREC) of Queensland University of Technology, Brisbane, Australia (Approval number 2000000177).

3. RESULTS

3.1. Health, demographic and feeding profile of the study sample

A total of 17,782 infants aged between 0 to 5.9 months were analysed in this study. A description of the study sample is presented in Table-1. The prevalence of common preventable illness was 33.6%. Over a third of infants aged below six months had malnutrition, and among malnourished infants, 44.7% (~15.4% of total population) had CFM.

More than two-thirds of children with CFM had either a coexistence of underweight with wasting or coexistence of underweight with stunting. The prevalence of coexistence of stunting with overweight/obesity in infants under six months was 14.6%.

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Continuation of breastfeeding in children aged below six-months was observed in more than 85% of infants. Early initiation of solid, semi-solid, and soft food practices before six months of age was reported from more than half of the sample. EBF was evident in 20.8% of infants, while the remainder were either SBF or weaned before six months of age (Table-1).

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Table-1: Demographic, health and feeding profile of children aged 0 to 5.9 months

Variable	Category	Frequency (%) (N=17,782)
Demographic profile		
Child age in months		2.59±1.65 months
Sex	Male	8981 (50.5%)
	Female	8801 (49.5%)
History of illness in past 14 days	No	11810 (66.4%)
	Yes	5972 (33.6%)
Maternal education	No education	9069 (51.1%)
	Primary	3155 (17.8%)
	Secondary or Higher	5225 (31.1%)
Wealth index	Poorest	4066 (22.9%)
	Poorer	3823 (21.5%)
	Middle	3717 (20.9%)
	Richer	3337 (18.8%)
	Richest	2839 (16.0%)
Type of place of residence	Rural	12088 (67.9%)
	Urban	5694 (32.1%)
Nutritional profile		
Total population	Healthy children	11651 (65.5%)
	Malnourished children	6131 (34.5%)
	Standalone forms of malnutrition	3,389 (19.1%)
	Coexisting forms of malnutrition	2,742 (15.4%)
Standalone forms of malnutrition (55.3%, n=3,389) *	Wasting∞	1594 (47%)
	Stunting∞	1083 (32%)
	Underweight∞	374 (11%)
	Overweight/obesity∞	338 (10%)
Coexisting forms of malnutrition (44.7%, n=2,742) *	Coexistence of underweight with wasting¥	846 (30.9%)
	Coexistence of underweight with stunting¥	1125 (41.1%)

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Variable	Category	Frequency (%) (N=17,782)
	Coexistence of underweight with wasting and stunting¥	368 (13.4%)
	Coexistence of stunting with overweight/obesity¥	403 (14.6%)
Feeding profile		
Feeding indicators		
Continuation of breastfeeding practices	No	2440 (13.7%)
	Yes	15342 (86.3%)
Predominant feeding (PF) practices	No	9693 (54.5%)
	Yes	8089 (45.5%)
Solid, & semisolid, food (SSF) practices	No	6716 (37.8%)
	Yes	11066 (62.2%)
Feeding practices		
Derived feeding practices	Exclusive breastfeeding (EBF)	3708 (20.8%)
	Supplementary breastfeeding (SBF)	11637 (65.4%)
	Weaning	2441 (13.7%)

*= Denominator for calculating standalone and coexisting forms of malnutrition was the prevalence of malnourished children in Pakistan (n=6,131).

∞= Denominator for calculating wasting, stunting, underweight, and overweight/obesity was the prevalence of standalone forms of malnutrition (n=3,389).

¥= Denominator for calculating coexistence of underweight with wasting, coexistence of underweight with stunting, coexistence of underweight with both wasting and stunting, and coexistence of stunting with overweight/obesity was the prevalence of coexisting forms of malnutrition (n=2,742).

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3.2. Associations between Feeding indicators and CFM

3.2.1. Association of continuation of breastfeeding with CFM.

Compared to infants who had not received breastmilk in the last 24 hours, infants with CBF had lower odds of coexistence of underweight with wasting, (0.52; 95% CI: 0.31 to 0.87); underweight with stunting, (0.50; 95% CI: 0.31 to 0.83), and underweight with both wasting and stunting (0.47 95% CI: 0.26 to 0.85), after adjustment for covariates. However, no association was observed between continuation of BF with coexistence of stunting with overweight/obesity (Table-2).

Table-2: Multinomial adjusted model for the associations between continuation of breastfeeding and CFM

Variable	Categories	Coexistence of underweight with wasting[1]	Coexistence of underweight with stunting[2]	Coexistence of underweight with wasting and stunting[3]	Coexistence of stunting with overweight/obesity [4]
Continuation of breastfeeding (CBF) practices	No	Ref	Ref	Ref	Ref
	Yes	0.52 (0.31 to 0.87) *	0.50 (0.31 to 0.83) *	0.47 (0.26 to 0.85) *	0.97 (0.75 to 1.24)
Age					0.97 (0.75 to 1.24)
Sex	Male		Ref	Ref	-
	Female		0.67 (0.53 to 0.85) *	0.72 (0.53 to 0.96) *	
Health status	No		-	-	Ref
	Yes				0.71 (0.55 to 0.91) *
Maternal education	No education			Ref	-
	Primary			0.67 (0.45 to 1.01)	
	Secondary or Higher			0.60 (0.40 to 0.89) *	
Socioeconomic status	Poorest	Ref		-	Ref
	Poorer	0.95 (0.68 to 1.32)			1.04 (0.74 to 1.45)
	Middle	1.12 (0.78 to 1.57)			1.15 (0.81 to 1.66)
	Richer	1.72 (1.48 to 2.60) *			1.44 (0.99 to 2.10)
	Richest	1.70 (1.06 to 2.71) *			1.82 (1.25 to 2.64) *
Type of place of residence	Rural	-		Ref	-
	Urban			1.58 (1.12 to 2.23) *	

1 = Adjusted for Exclusive breastfeeding practices with socioeconomic status.
2 = Adjusted for Exclusive breastfeeding practices with child sex.
3 = Adjusted for Exclusive breastfeeding practices with child sex, maternal education, and type of place of residence.
4 = Adjusted for Exclusive breastfeeding practices with child age, health status, and socioeconomic status.

3.2.2. Association of predominant feeding with CFM.

Predominant feeding in infants aged below six-months was not associated with any form of CFM (Table-3).

Table-3: Multinomial adjusted model for the associations between predominant feeding and CFM

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Variable	Categories	Coexistence of underweight with wasting	Coexistence of underweight with stunting	Coexistence of underweight with wasting and stunting	Coexistence of stunting with overweight/obesity
Predominant feeding (PF) practices	No	Ref	Ref	Ref	Ref
	Yes	1.09 (0.85 to 1.40)	0.87 (0.69 to 1.11)	1.12 (0.83 to 1.51)	0.81 (0.62 to 1.03)
Age					0.89 (0.82 to 0.97) *
Sex	Male		Ref	Ref	-
	Female		0.68 (0.54 to 0.86) *	0.73 (0.54 to 0.98) *	
Health status	No			-	Ref
	Yes				0.70 (0.55 to 0.90) *
Maternal education	No education			Ref	-
	Primary			0.66 (0.44 to 0.99) *	
	Secondary or Higher			0.62 (0.41 to 0.92) *	
Socioeconomic status	Poorest	Ref	-	-	Ref
	Poorer	0.96 (0.69 to 1.34)			1.05 (0.75 to 1.46)
	Middle	1.15 (0.81 to 1.63)			1.17 (0.81 to 1.67)
	Richer	1.79 (1.19 to 2.71) *			1.46 (1.01 to 2.12) *
	Richest	1.82 (1.14 to 2.90) *			1.81 (1.25 to 2.62) *
Type of place of residence	Rural	-		Ref	-
	Urban			1.51 (1.07 to 2.13) *	

1 = Adjusted for Predominant feeding practices with socioeconomic status.
2 = Adjusted for Predominant feeding practices with child sex.
3 = Adjusted for Predominant feeding practices with child sex, maternal education, and type of place of residence.
4 = Adjusted for Predominant feeding practices with child age, health status, and socioeconomic status.

3.2.3. Association of solid, semi-solid & soft food with CFM.

Introduction of solid, semi-solid, and soft food during the first six-months of life lowered the odds of coexistence of underweight with stunting to 0.66 (0.51 to 0.86) after adjusting for the sex of the child. However, no associations were found between the early introduction of solid, semi-solid, & soft food and other forms of CFM, (Table-4).

Table-4: Multinomial adjusted model for associations between use of solid, semi-solid & soft foods and CFM.

Variable	Categories	Coexistence of underweight with wasting	Coexistence of underweight with stunting	Coexistence of underweight with wasting and stunting	Coexistence of stunting with overweight/obesity
		Adjusted Odds[3] (95% CI)	Adjusted Odds[3] (95% CI)	Adjusted Odds[3] (95% CI)	Adjusted Odds[3] (95% CI)
Solid, & semisolid, food (SSF) practices	No	Ref	Ref	Ref	Ref
	Yes	1.05 (0.80 to 1.40)	0.66 (0.51 to 0.86) *	1.03 (0.74 to 1.44)	1.04 (0.81 to 1.32)
Age					0.87 (0.81 to 0.94) *
Sex	Male		Ref	Ref	-
	Female		0.67 (0.53 to 0.85) *	0.73 (0.54 to 0.98) *	
Health status	No			-	Ref
	Yes				0.71 (0.55 to 0.91) *
Maternal education	No education			Ref	-
	Primary			0.65 (0.44 to 0.97) *	
	Secondary or Higher			0.61 (0.41 to 0.91) *	
Socioeconomic status	Poorest	Ref		-	Ref
	Poorer	0.97 (0.69 to 1.35)			1.04 (0.74 to 1.45)
	Middle	1.15 (0.81 to 1.62)			1.15 (0.80 to 1.65)
	Richer	1.78 (1.18 to 2.68) *			1.44 (0.99 to 2.09)
	Richest	1.80 (1.13 to 2.87) *			1.82 (1.25 to 2.64) *

Type of place of residence	Rural	-	Ref	-
	Urban		1.52 (1.08 to 2.15) *	

1 = Adjusted for Solid and Semi-solid food feeding practices with socioeconomic status.
2 = Adjusted for Solid and Semi-solid food feeding practices with child sex.
3 = Adjusted for Solid and Semi-solid food feeding practices with child sex, maternal education, and type of place of residence.
4 = Adjusted for Solid and Semi-solid food feeding practices with child age, health status, and socioeconomic status.

3.3. Associations between feeding practices and coexisting forms of malnutrition

This section presents the findings of associations between all feeding practice categories (EBF, supplementary feeding (breastmilk with infant formula; breastmilk with animal milk; breastmilk with water, juice, broth, and other liquid, and breastmilk with solid, semi-solid, and soft food) and completely weaned) and each CFM.

3.3.1. Coexistence of underweight with wasting

Multivariable analysis of the datasets showed around two-folds higher odds (95% CI: 1.12 to 3.47) of coexistence of underweight with wasting among weaned infants compared to EBF infants after adjustment for covariates (Table-5). On sensitivity analysis, breastfeeding with infant formula, breastfeeding with animal milk, breastfeeding with water, juice, broth, and other liquid, and breastfeeding with solid, semi-solid, and soft food showed no association with the coexistence of underweight with wasting **(Supplementary-file-4, Table-S4-A)**

3.3.2. Coexistence of underweight with stunting

There was no association between the coexistence of underweight with stunting and any SBF categories or complete weaning practices (Table-5). Similarly, in a sensitivity analysis, no association of coexistence of underweight with stunting was reported with any type of SBF practice **(Supplementary-file-4, Table-S4-B).**

3.3.3. Coexistence of underweight with wasting and stunting

Compared to EBF infants, weaned neonates and infants had more than twice the odds (2.25; 95% CI: 1.16 to 4.36) of coexistence of underweight with both wasting and stunting. In a sensitivity analysis, we did not find associations between the coexistence of underweight with both wasting & stunting and various forms of SBF: coadministration of breastfeeding with infant formula, or animal milk, or water & juice, or solid & semi-solid food **(Supplementary-file-4, Table-S4-C).**

3.3.4. Coexistence of stunting with overweight/obesity

Compared to EBF infants, there were lower odds of coexistence of stunting with overweight/obesity (0.71, 95% CI: 0.51 to 0.97) among SBF infants but no association between coexistence of stunting with overweight/obesity and complete weaning practices. (Table-5). Coexistence of stunting with overweight/obesity was not associated with any type of SBF, such as coadministration of breastfeeding with infant formula, or animal milk, or water & juice, or solid & semi-solid food **(Supplementary-file-4, Table-S4-D)**

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Table-5: Multinomial adjusted model for assessing the determinants of coexisting forms of malnutrition

Variable	Categories	Coexistence of underweight with wasting ¥	Coexistence of underweight with stunting¥	Coexistence of underweight with wasting and stunting ¥	Coexistence of stunting with overweight/obesity ∞
Feeding practices[1]	Exclusive breastfeeding (EBF)	Ref	Ref	Ref	Ref
	Supplementary breastfeeding (SBF)	1.10 (0.81 to 1.51)	0.84 (0.63 to 1.14)	1.16 (0.78 to 1.71)	0.71 (0.51 to 0.97) *
	Early initiation of weaning	1.96 (1.12 to 3.47) *	1.65 (0.95 to 2.85)	2.25 (1.16 to 4.36) *	0.81 (0.58 to 1.12)
Age					0.89 (0.82 to 0.96) *
Sex	Male		Ref	Ref	-
	Female		0.67 (0.53 to 0.85) *	0.72 (0.53 to 0.97) *	
Health status	No	-			Ref
	Yes			-	0.71 (0.55 to 0.90) *
Maternal education	No education			Ref	-
	Primary			0.68 (0.46 to 1.02)	
	Secondary or Higher			0.61 (0.41 to 0.91) *	
Socioeconomic status	Poorest	Ref	-	-	Ref
	Poorer	0.95 (0.68 to 1.33)			1.03 (0.74 to 1.45)
	Middle	1.11 (0.78 to 1.57)			1.18 (0.82 to 1.70)
	Richer	1.73 (1.15 to 2.61) *			1.48 (1.01 to 2.15) *
	Richest	1.70 (1.06 to 2.72) *			1.88 (1.29 to 2.74) *
Type of place of residence	Rural	-		Ref	-
	Urban			1.58 (1.12 to 2.24) *	

¥ = Reference is underweight

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∞ = Reference in stunting
1 = Model adjusted for infant feeding practices and socioeconomic status.
2 = Model adjusted for infant feeding practices and child sex.
3 = Model adjusted for infant feeding practices child sex, maternal education, and type of place of residence.
4 = Model adjusted for infant feeding practices child age, health status, and socioeconomic status

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4. Discussion

This is the first study to examine the benefits of continuation of BF and EBF among infants aged below six-months for protection against various types of CFM. In this study, the relationship of various types of CFM with feeding indicators (continuation of breastmilk, PF, and SSF) and feeding practices (EBF, SBF, early initiation of weaning) among infants aged below six-months was presented in detail. Ten different national and regional datasets were used to examine CFM among infants aged between 0 to 5.9 months. Altogether, we found malnutrition in over one-third of infants, of which half had CFM.

Findings indicate a protective role of continuation of breastfeeding for coexisting forms of undernutrition: coexistence of underweight with wasting, coexistence of underweight with stunting, and coexistence of underweight with both wasting & stunting. However, we found no association with the coexistence of stunting with overweight/obesity and breastfeeding. Similarly, a study conducted in Thailand showed no association of breastfeeding with the coexistence of stunting with overweight/obesity [33]. Conversely, a study by Oddo, et al. (2012), reported significantly lowered odds of coexistence of stunting with overweight/obesity in children among breastfed children in Bangladesh and Indonesia [34]. Other studies, including a systematic review and meta-analysis found lower likelihood of both undernutrition as well as overnutrition for breastfed infants [35, 36]. The lack of association between breastfeeding and coexistence of stunting with overweight/obesity in this study might be affected by SBF, because the practice of SBF in infants reduce the risk of coexistence of stunting with overweight/obesity by 0.71 (0.51 to 0.97).

Based on three feeding indicators proposed in IYCF guidelines, this study further investigated the relationship of CFM with three different types of feeding practices: EBF, SBF, and complete weaning practices. SBF and complete weaning practices are pivotal barriers for effective EBF adherence during the first six months of life [38]. This study found that compared to EBF, complete weaning practices before six-months of child age significantly increased the odds of coexistence of both underweight with wasting, and coexistence of underweight with wasting and stunting by two-to-three-fold in young infants. Similarly, studies conducted in Denmark, Indonesia, and Pakistan also found that complete weaning increased the risk of malnutrition among infants [39-42]. Conversely, a study in India demonstrated that complete weaning practices protected young infants from stunting [43]. This study found no association between complete weaning practices and neither coexistence of underweight with stunting nor coexistence of stunting with overweight/obesity. This was consistent with a study conducted by Shaili, et al., (2014), who reported no association of complete weaning practices with pediatric malnutrition, but a significant relationship between food quality and food quantity and infant nutritional status[44].

We found that over 85% infants of Pakistan continued to receive maternal breastmilk until six-months of age. However, less than a quarter of infants were exclusively breastfed at six months of age. At this stage of development, the National Nutritional Surveys (NNS) of Pakistan (conducted by UNICEF) have reported EBF rates ranging from 38% in 2011 NNS to 50% in 2001 [45]. Similarly, the PDHS reported EBF rates of 25% in 1990-1991, followed by 37% in 2006-2007, 38% in 2012-2013, and

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48% in 2017-2018, respectively [23, 24]. Currently, Pakistan has an EBF rate of 48%, which is close to but under the global target of 50% defined by World Health Assembly [45]. Furthermore, this study reported that the recommended practice of EBF has been substituted by SBF (65.4%) and complete weaning practices (13.7%). Surprisingly, this study reported no association between any type of SBF with any form of CFM. However, different studies and reviews have demonstrated adverse nutritional consequences, such as micronutrient deficiencies, juvenile adiposity, and undernutrition among infants using either formula milk and/or animal milk and/or juices/water/broth and/or solid/semi-solid/soft foods [46-48]. Lack of association between various types of SBF and CFM in our study might be due to the cross-sectional study design and social desirability bias, or overreporting of socially desirable behaviors during an interview and survey [49]. The social desirability biasness of the participants can be controlled by conducting indirect questioning, qualitative research and intervention trials [50, 51].

Infants of richer/richest socioeconomic strata are more vulnerable to CFM compared to infants of poorer/poorest socioeconomic strata. Our study found 1.70 (1.06 to 2.72) and 1.88 (1.29 to 2.74) fold higher odds of coexistence of underweight with wasting, and coexistence of stunting with overweight/obesity in infants of the wealthiest (high) socioeconomic status, compared to infants of the lowest socioeconomic status. In a prospective cohort study by Wijlaars, et al. (2011), it was also reported that infants of low socioeconomic status at three months of age showed a significant increase in weight and height compared to infants of high socioeconomic status [52]. This relationship may change depending on the age of the child as a recent previous study found that an improvement in socioeconomic status protects infants and children below five years of age from CFM [14]. Similarly, many previous studies have found that an improvement in socioeconomic status prevents various types of nutritional disorders in children, including CFM [26, 53-55]. Further research is needed on whether there could be differences across the age of the child.

Study strength and limitations

To best of our knowledge, this is the first study to examine the relationship of infant feeding practices (EBF, SBF, and early initiation of weaning) with CFM among infants aged below six-months. This study analysed ten different national and regional datasets of Pakistan, and these datasets contained data from over 10,000 children. Despite the large sample size, cross-sectional study design limits affect the of our findings. Temporal and casual relationships between the CFM and different feeding practices of infants aged below six-months could not be assessed. Further, information related to feeding indicators and feeding practices solely relied on verbal responses of the participants. A food list was used for collecting data pertaining to infant feeding indicators and practices, and this food list for data collection response may have compromised the validity and reliability of responses and specifically in terms of recall bias. Moreover, these surveys did not collect data related to food quantity, thus restricting us to measure the association of CFM with total caloric intake.

Conclusions

Pediatric malnutrition is a chronic issue in Pakistan, which affects more than a third of infants aged below six months. Among malnourished infants, around half are susceptible to various forms of CFM. More than two-thirds of mothers breastfeed their infants, but less than a quarter practiced EBF. Breastmilk continuation protects infants from various forms of CFM, while early initiation of weaning significantly increased the risk of coexistence of underweight with wasting and coexistence of underweight with both wasting and stunting. In contrast, the practice of SBF showed no association with any forms of CFM, except coexistence of stunting with overweight/obesity. Altogether, this study found that continuation of maternal breastmilk during the first six-months of life protects infants from various forms of malnutrition, including CFM. Strict policies against formula milk marketing, sales and prescribing can prevent augmented cases of SBF and early weaning before six-months, to protect infants from various types of malnutrition, including CFM.

Supplementary Materials: ***Supplementary file 1:*** Described the process of data screening, data cleaning, and data transformation using PDHS and MICS datasets. ***Supplementary file 2:*** Showed different infant feeding variables and their use for defining various types of infant feeding indicators, infant feeding practices and four different types of SBF. ***Supplementary file 3:*** Presented the unadjusted odds for assessing the determinants of various forms of coexisting forms of malnutrition. ***Supplementary file 4:*** Measured the association of each form of Supplementary breastfeeding with the various forms of coexisting forms of malnutrition.

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Reference

1. Khaliq A, Qamar M, Hussaini SA, Azam K, Zehra N, Hussain M, et al. Assessment of knowledge and practices about breastfeeding and weaning among working and non-working mothers. Journal of the Pakistan Medical Association. 2017;67(3):332-8.
2. Di Benedetto MG, Bottanelli C, Cattaneo A, Pariante CM, Borsini A. Nutritional and immunological factors in breast milk: A role in the intergenerational transmission from maternal psychopathology to child development. Brain, behavior, and immunity. 2020;85:57-68.
3. Yi DY, Kim SY. Human Breast Milk Composition and Function in Human Health: From Nutritional Components to Microbiome and MicroRNAs. Nutrients. 2021;13(9):3094.
4. Sohail J, Khaliq A. KNOWLEDGE, ATTITUDE AND PRACTICE OF MOTHERS REGARDING COLOSTRUM FEEDING TO NEWBORNS IN RURAL PAKISTAN: A CROSS-SECTIONAL STUDY. Khyber Medical University Journal. 2017;9(4).
5. Chai Y, Nandi A, Heymann J. Does extending the duration of legislated paid maternity leave improve breastfeeding practices? Evidence from 38 low-income and middle-income countries. BMJ global health. 2018;3(5):e001032.
6. World Health O. Indicators for assessing infant and young child feeding practices: part 1: definitions: conclusions of a consensus meeting held 6-8 November 2007 in Washington DC, USA: World Health Organization; 2008.
7. Eidelman AI, Schanler RJ. Breastfeeding and the use of human milk. Pediatrics. 2012.
8. World Health Organization. Interventions by global target [Available from: https://www.who.int/elena/global-targets/en/.
9. Brodribb W, Miller Y. Introducing solids and water to Australian infants. Journal of Human Lactation. 2013;29(2):214-21.
10. Garrison MP, Maisano P. Systematic Review of Factors Influencing Non–Medically Indicated Formula Supplementation of Newborns in the Hospital Setting. Nursing for Women's Health. 2019;23(4):340-50.
11. Bewket Zeleke L, Welday Gebremichael M, Mehretie Adinew Y, Abebe Gelaw K. Appropriate Weaning Practice and Associated Factors among Infants and Young Children in Northwest Ethiopia. Journal of Nutrition and Metabolism. 2017;2017:9608315.
12. Falkner F. Infant and child nutrition worldwide: issues and perspectives: CRC Press; 1991.
13. Khaliq A, Wraith D, Nambiar S, Miller Y. A review of the prevalence, trends, and determinants of coexisting forms of malnutrition in neonates, infants, and children. BMC Public Health. 2022;22(1):879.
14. Khaliq A, Wraith D, Miller Y, Nambiar-Mann S. Prevalence, trends, and socioeconomic determinants of coexisting forms of malnutrition amongst children under five years of age in Pakistan. Nutrients. 2021;13(12):4566.
15. United Nations Children's Funds. National Nutrition Survey 2018, Key Finding Report. . 2019.
16. Akhtar S. Malnutrition in South Asia—A critical reappraisal. Critical reviews in food science 2016;56(14):2320-30.
17. Stephenson LS, Latham MC, Ottesen EA. Global malnutrition. Parasitology. 2000;121(S1):S5-S22.
18. Demilew YM, Tafere TE, Abitew DB. Infant and young child feeding practice among mothers with 0–24 months old children in Slum areas of Bahir Dar City, Ethiopia. International breastfeeding journal. 2017;12(1):26.
19. Kolčić I. Double burden of malnutrition: A silent driver of double burden of disease in low–and middle–income countries. J Journal of global health. 2012;2(2).
20. Goates S, Du K, Braunschweig CA, Arensberg MB. Economic burden of disease-associated malnutrition at the state level. PLoS One. 2016;11(9).
21. Jones G, Steketee RW, Black RE, Bhutta ZA, Morris SS. How many child deaths can we prevent this year? The lancet. 2003;362(9377):65-71.
22. World Health Organisation. Children: reducing mortality. 2019 [cited 2020 March, 27th]. Available from: https://www.who.int/news-room/fact-sheets/detail/children-reducing-mortality.
23. Pakistan Demographic and Health Survey. PAKISTAN DEMOGRAPHIC AND HEALTH SURVEY 2017-18. . 2019.
24. National Institute of Population Studies NP. Pakistan Demographic and Health Survey 1990-1991. 1991.
25. United nations Children Funds. Surveys : Multiple Indicator Cluster Surveys 2020 [updated 2020; cited 2020 April, 17th]. Available from: http://mics.unicef.org/surveys.
26. Khaliq A, Wraith D, Miller Y, Nambiar-Mann S. Prevalence, Trends, and Socioeconomic Determinants of Coexisting Forms of Malnutrition Amongst Children under Five Years of Age in Pakistan. Nutrients. 2021;13(12).

27. Mei Z, Grummer-Strawn LM. Standard deviation of anthropometric Z-scores as a data quality assessment tool using the 2006 WHO growth standards: a cross country analysis. J Bulletin of the World Health Organization. 2007;85:441-8.
28. World Health O. Recommendations for data collection, analysis and reporting on anthropometric indicators in children under 5 years old. 2019.
29. Vanderwall C, Clark RR, Eickhoff J, Carrel AL. BMI is a poor predictor of adiposity in young overweight and obese children. BMC pediatrics. 2017;17(1):1-6.
30. Zhang Y, Huang X, Yang Y, Liu X, Yang C, Wang A, et al. Double burden of malnutrition among children under 5 in poor areas of China. PLoS One. 2018;13(9):e0204142.
31. World Health Organization. Infant and young child feeding 2021 [Available from: https://www.who.int/news-room/fact-sheets/detail/infant-and-young-child-feeding.
32. Organization WH. Indicators for assessing infant and young child feeding practices: part 2: measurement. 2010.
33. Benedict L, Hong SA, Winichagoon P, Tejativaddhana P, Kasemsup V. Double burden of malnutrition and its association with infant and young child feeding practices among children under-five in Thailand. Public Health Nutrition. 2021;24(10):3058-65.
34. Oddo VM, Rah JH, Semba RD, Sun K, Akhter N, Sari M, et al. Predictors of maternal and child double burden of malnutrition in rural Indonesia and Bangladesh. 2012;95(4):951-8.
35. Kramer MS, Kakuma R. Optimal duration of exclusive breastfeeding. Cochrane database of systematic reviews. 2012(8).
36. Grummer-Strawn LM, Mei Z. Does Breastfeeding Protect Against Pediatric Overweight? Analysis of Longitudinal Data From the Centers for Disease Control and Prevention Pediatric Nutrition Surveillance System. Pediatrics. 2004;113(2):e81-e6.
37. Khaliq A, Qamar M, Hussaini SA, Azam K, Zehra N, Hussain M, et al. Assessment of knowledge and practices about breastfeeding and weaning among working and non-working mothers. JPMA The Journal of the Pakistan Medical Association. 2017;67(3):332-8.
38. Hirano AR, Baggio MA, Ferrari RAP. BREASTFEEDING, SUPLEMENTARY FEEDING AND FOOD AND NUTRITION SECURITY IN A BORDER. Cogitare Enfermagem. 2021;26.
39. Shamim S, Naz F, Jamalvi SW, Ali SSJJCPSP. Effect of weaning period on nutritional status of children. 2006;16(8):529-31.
40. Foote KD, Marriott LD. Weaning of infants. Archives of disease in childhood. 2003;88(6):488-92.
41. Putri ES, Siregar SMF, Husna A, Marniati M, Darmawan D. Relation of Dietary Habits and Weaning with Nutritional Status of Children. J-Kesmas: Jurnal Fakultas Kesehatan Masyarakat (The Indonesian Journal of Public Health). 2020;7(2):28-33.
42. Ishmah A. HUBUNGAN BERAT BAYI LAHIR, USIA PENYAPIHAN, TINGKAT KECUKUPAN ENERGI DENGAN KEJADIAN STUNTING PADA BALITA DI DESA JATISONO, KECAMATAN GAJAH, KABUPATEN DEMAK. 2017.
43. Padmadas SS, Hutter I, Willekens F. Weaning initiation patterns and subsequent linear growth progression among children aged 2–4 years in India. International Journal of Epidemiology. 2002;31(4):855-63.
44. Vyas S, Kandpal S, Semwal J, Chauhan S, Nautiyal VJIjopm. Trends in weaning practices among infants and toddlers in a hilly terrain of a newly formed state of India. 2014;5(6):741.
45. Nutrition Wing MoNHS, Regulation and Coordination, Government of Pakistan,. National Nutrition Survey 2018 - Key Findings Report. 2019.
46. Shamim S, Naz F, Jamalvi SW, Ali SS. Effect of weaning period on nutritional status of children. Journal of the College of Physicians and Surgeons--Pakistan : JCPSP. 2006;16(8):529-31.
47. Sonneville KR, Long MW, Rifas-Shiman SL, Kleinman K, Gillman MW, Taveras EM. Juice and water intake in infancy and later beverage intake and adiposity: could juice be a gateway drink? Obesity (Silver Spring, Md). 2015;23(1):170-6.
48. Ziegler EE. Adverse effects of cow's milk in infants. Nestle Nutrition workshop series Paediatric programme. 2007;60:185-99.
49. Latkin CA, Edwards C, Davey-Rothwell MA, Tobin KE. The relationship between social desirability bias and self-reports of health, substance use, and social network factors among urban substance users in Baltimore, Maryland. Addictive behaviors. 2017;73:133-6.
50. Khaliq A, Amreen, Jameel N, Krauth SJ. Knowledge and Practices on the Prevention and Management of Diarrhea in Children Under-2 Years Among Women Dwelling in Urban Slums of Karachi, Pakistan. Matern Child Health J. 2022;26(7):1442-52.
51. Meisters J, Hoffmann A, Musch JJPo. Controlling social desirability bias: An experimental investigation of the extended crosswise model. 2020;15(12):e0243384.
52. Wijlaars LPMM, Johnson L, van Jaarsveld CHM, Wardle J. Socioeconomic status and weight gain in early infancy. International Journal of Obesity. 2011;35(7):963-70.

 doi:10.20944/preprints202209.0087.v1

53. Ahmad D, Afzal M, Imtiaz AJFBJ. Effect of socioeconomic factors on malnutrition among children in Pakistan. 2020;6(1):1-11.
54. Qureshi R. Socio-Demographic Factors Associated with Malnutrition Among Children Less Than Five Years. J Annals of Punjab Medical College. 2019;13(2):181-4.
55. Ali A, Hussain SA. THE IMPACT OF HOUSEHOLD SOCIO-ECONOMIC STATUS ON CHILD STUNTING IN PAKISTAN. 2021:93.
56. Di Prima S, Wright EP, Sharma IK, Syurina E, Broerse JEJGFS. Implementation and scale-up of nutrition-sensitive agriculture in low-and middle-income countries: a systematic review of what works, what doesn't work and why. 2022;32:100595.
57. Mosha D, Canavan CR, Bellows AL, Blakstad MM, Noor RA, Masanja H, et al. The impact of integrated nutrition-sensitive interventions on nutrition and health of children and women in rural Tanzania: study protocol for a cluster-randomized controlled trial. 2018;4(1):1-8.
58. Putri ES, Siregar SMF, Husna A, Marniati M, Darmawan DJJ-KJFKM. Relation of Dietary Habits and Weaning with Nutritional Status of Children. 2020;7(2):90-5.
59. Dinour LM, Szaro JM. Employer-based programs to support breastfeeding among working mothers: a systematic review. Breastfeeding medicine. 2017;12(3):131-41.
60. Bresnahan M, Zhu Y, Zhuang J, Yan X. "He wants a refund because I'm breastfeeding my baby": A thematic analysis of maternal stigma for breastfeeding in public. Stigma and Health. 2020;5(4):394.