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Malnutrition and its Related Factors among Children under Five Years of Age

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Abstract

Background: Malnutrition is one of public health concerns among children leading to high morbidity and mortality. The present study aimed to determine the prevalence and the determinants of malnutrition among under-five-year-old children in Zahedan, Iran.

Methods: This cross-sectional study included under-five children and their mothers who attended Zahedan comprehensive urban health centers. The participants were recruited from a quota sampling. Data on the characteristics of children and mothers were obtained from the child care records, and maternal reporting when necessary. Weight and height of children were measured according to the standard protocol by a trained person. Malnutrition was measured in terms of underweight, stunting and wasting. Multivariable logistic regression analysis and the area under the curve (AUC) were used to identify determinants of malnutrition.

Results: A total of 825 mother-child pairs were included. Prevalence of underweight, stunting and wasting was 7.6%, 20.6% and 5.8%, respectively. The results of multivariable analysis revealed that underweight may be predicted by mother's education, low birth weight (LBW), birth interval, nutrition style, age of introduction of complementary feeding (AUC=0.75); stunting by sex, age, maternal age, father's education, family size, LBW, birth order and nutrition style (AUC=0.67) and wasting by sex, age, mother's education, LBW and nutrition style (AUC=0.72). LBW was a significant shared determinant in the nomograms with an odds ratio of over 2.00.

Conclusion: Our findings demonstrate a moderate to high prevalence of malnutrition and identify a combination of parent's educational attainment, LBW, birth order, birth interval and nutritional practice as determinants of malnutrition among children under five years of age, in Zahedan.

Key Words: Malnutrition, Preschool children, Risk factors, Zahedan.

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1- INTRODUCTION

Malnutrition is still a global major cause of morbidity and mortality among under-five children (1). It is estimated that 50% of the mortality due to preventable and treatable illnesses and 11% of disability-adjusted life years (DALY) among children are attributed to malnutrition (2). Moreover, children's malnutrition can be associated with later life health consequences (3). There is a worldwide inequality in the burden of malnutrition so that the highest burden of malnutrition was observed among South-East Asia and sub-Saharan Africa countries (4, 5), however, it is still a major challenge in other regions such as Middle East as recent evidence indicates a total prevalence of 19% (6).

In Iran, the last data has shown that the national prevalence of underweight and wasting has decreased to 6% and 4%, respectively (7); however, there is a great variability in the prevalence of under-five malnutrition at finer geographical levels. Provinces located in western areas had a lower prevalence of malnutrition indices while those in the northern and eastern area showed higher prevalence (8). It is probably due to experiencing rapid epidemiologic and demographic transition and probably nutritional status transformation in different areas in Iran (9).

Although several studies have investigated the prevalence of malnutrition indices in Iran (10, 11), few studies have been conducted to assess the factors associated with malnutrition indices including stunting, wasting and underweight among children, separately. Identifying the determinants of malnutrition indices is highly recommended because each index shows different types of nutritional status in a child, e.g. wasting (Weight-for-Height) and stunting (Height-for-age) describe acute malnutrition and chronic malnutrition, respectively, while underweight (Weight-for-age) is a composite index of wasting and stunting. Previous studies suggested that child characteristics including low birth weight (12), birth order (12) or birth interval (13) and socio-demographic factors (14) may be associated with stunting, wasting and underweight.

What is taken from the literature is that there are few studies which attempt to develop a nomogram for identifying malnutrition; or investigate the most important determinants of underweight, stunting and wasting, simultaneously, especially in Zahedan, Iran. Therefore, the aims of the current study were to a) estimate the prevalence of malnutrition indices, b) identify the determinants of malnutrition indices and develop nomograms for estimating the individual probability of each malnutrition index among under-five children in Zahedan, Iran.

2- MATERIAL & METHODS

2-1. Study design

This was a cross-sectional study, which was carried out from January 2017 to September 2017 in suburban areas of Zahedan, Iran. Zahedan city is the center of the deprived province of Sistan and Baluchestan, Southeastern, Iran.

2-2. Sampling

The single proportion formula was applied to determine the required minimum sample size (expected prevalence=9.5%, precision=0.02 and $z_{1-\frac{\alpha}{2}}$=1.96). Considering these assumptions, 825 children under 5 years of age were recruited for the study.

In Zahedan, there are 23 comprehensive urban health centers. Among those in suburban areas two centers were selected. In a quota sampling, the sample of 825 under-five children were recruited from two aforementioned centers. The participants were selected from infants and children who referred to centers for taking health care services and met the inclusion criteria.

2-3. Inclusion criteria

Being a 5-year-old child not suffering from psychomotor retardation, congenital anomalies such as cleft lip, cleft palate or any disease that disrupts the child's nutrition with a mother not suffering from mental disorders. There was no limitation on ethnicity.

2-4. Data collection

Socio-demographic, child characteristics and nutrition practice information were obtained using a predefined checklist. The checklist was filled by the trained investigator through extracting information from the registered healthcare records for each child; however, maternal self-report was considered when the required information could not be extracted from the records. The checklist comprised of the following study variables: age (under 1 year old and 1 to 5 years old), gender (male and female), Maternal age (< 18 years old, 18 to 35 and > 35), Parents' education (Illiterate, primary education, secondary education, Diploma, Academic), Family size (≤ 5 and > 5), Birth weight (> 2500 gr and < 2500 gr), Birth interval (first child, <3 and ≥ 3), Birth order (≤ 3, 4 to 6 and ≥ 7), Nutrition style (breastfeeding, Formula feeding and Both), and Age of introduction of complementary feeding (> 6 years old, 4 to 6 and < 4).

Weight and height in children aged under 2 years of age were measured lying down or in a sitting position. Weight was measured using a digital electronic weighing scale to the nearest 100 g with minimal clothing, without shoes. For children aged 2 to 5 years, height was measured in a standing position, without shoes, while the shoulders were in a normal position using height board or stadiometer. The measurements were performed by a trained person.

The measured weight and height data were transformed into Z-scores. According to Z-scores, three types of malnutrition including underweight (deficiency of weight for age; WAZ), stunting (deficiency of height for age; HAZ), and wasting (deficiency of weight for height; WHZ) were defined, based on the standard deviation (SD) of the median of reference population by WHO-2006. Underweight, stunted and wasted children were defined when the Z scores were equal to or less than -2 standard deviation (Z-score <-2), otherwise the case was defined as normal children (14, 15).

2-5. Statistical analyses

The variables were described as mean (±SD) or number (percent). Initially, univariate binary logistic models were developed to evaluate the unadjusted effect of the studied independent variables on the odds of being underweight, stunting and wasting, separately. The multivariable binary logistic regression model was developed after screening for statistically significant variables with p-value ≤0.20 in univariate analyses. The degree of sparse data bias was also considered e.g. 0 cases in the contingency table for the combination of determinants-outcome. To resolve this bias, the firth bias adjustment was used with adding 0.05 to each cell of the contingency table. The results of logistic regressions were presented as odds ratio (OR) and with 95% confidence interval (CI). Internal validity of the derived models in multivariable analyses was checked using bootstrapping with 1000 resamples. By bootstrapping, the resulting effect estimates with 95% CI correct for model uncertainty and optimism. Regression estimates in multivariable analyses after bootstrapping were used to generate diagnostic nomograms. The discrimination power of the nomograms was assessed using the area under the receiver operating characteristics (AUROC) curve. A P-value of $\leq$0.05 was considered statistically significant. The statistical analyses were performed using the STATA version 14.0.

3- RESULTS

3-1. Prevalence of malnutrition

From among 825 study participants, 425 (51.5%) were female and 400 (48.5%) were male, with 216 (47.3%) and 194 (52.7%) of whom were under 1 years old, respectively. Mean (±SD) of weight and height were 11.17 (2.5) kg, and 83 (10.93) cm, respectively. The prevalence (95% CI) of underweight, stunting and wasting were 7.6% (6%, 9%), 20.6% (18%, 23%), and 5.8% (4%, 7%), respectively (8.8%, 23% and 7% for boys and 6.6%, 18.4% and 4.7% for girls)

3-2. Characteristics of the Participants

The characteristics of the study participants according to underweight, stunting and wasting as well as unadjusted ORs (95% CI) are shown in **Table 1**. In the univariate analysis, the mother's academic education (0.26% vs. 1.61%, p=0.04), LBW (9.74% vs. 32.79%, p<0.001), birth interval lower than 3 years (35.17% vs. 56.45%, p=0.02), formula feeding (3.81% vs. 14.25%, p<0.001), and age of introduction of complementary feeding below 4 months (4.60% vs. 9.68%, p=0.03) among underweight children were significantly higher than those of normal children.

Stunted children were significantly higher among those with mothers aged under 18 years (15.42% vs. 23.67%, p=0.006), and LBW (9.05% vs. 21.30%, p<0.001), in comparison to normal children. However, stunted children were less among those with a family size of over 5 (37.40% vs. 22.49%, p<0.001), and birth order over or equal to 7 (5.04% vs. 1.18%, p=0.03), compared to normal children. One to five years of age (48.91% vs. 72.92%, p=0.002), the mother's academic education (0.26% vs. 2.08%, p=0.04) and LBW (10.71% vs. 25.53%, p=0.003) among wasted children were significantly higher than those in normal children.

3-3. Determinants of malnutrition

The results of multivariable binary logistic analysis and bootstrapped estimates are presented in **Table 2**. The Multivariable binary logistic analysis showed that the Mother's academic education (aOR=14.73; 95%CI: 1.26, 172.27), LBW (4.87; 2.63, 9.01), and birth interval of less than 3 (2.93; 1.67, 5.13), formula feeding (3.92; 1.67, 9.20) were positively associated with underweight malnutrition. The odds of being stunted were significantly increased by 2.65 times (95% CI: 1.63, 4.33) among LBW. In contrast, the father's education with diploma level (0.40; 0.21, 0.79) and the family size of higher than 5 (0.35; 0.15, 0.83) were negatively associated with stunting malnutrition. Similarly, the results demonstrated that children aged 2 to 5 years old (3.11; 1.57, 6.15), those with a mother with academic education (24.45; 2.00, 298.21) and LBW (3.18; 1.55, 6.52) had higher odds of being wasting.

3-4. Nomogram, discrimination and validation

Nomograms for the diagnosis of underweight, stunting and wasting using all included characteristics in multivariable logistic regression analysis are presented in **Figures 1-3**, respectively. The AUCs (95% CI) of underweight for the model with all characteristics included in multivariable analysis and for the model with only the significant characteristics were 0.75 (0.68, 0.81) and 0.73 (0.67, 0.80), respectively; the p-value for the difference between the two AUCs was 0.16. Corresponding figures for stunting were 0.67 (0.63, 0.72) and 0.64 (0.59, 0.68) respectively, p=0.004 and for wasting were 0.72 (0.66, 0.79), and 0.69 (0.62, 0.75) respectively, p=0.11.

The effect estimates of the observed dataset were similar to that of the bootstrapped model, which provide evidence on the internal validation of derived final model; however, in some estimated CIs from bootstrapping show much less variability in comparison to that of the original model. There is no difference between AUCs before and after bootstrapping as the AUCs for discrimination of underweight, stunting and wasting were 0.75, 0.67 and 0.72, respectively after bootstrapping. The interpretation of nomogram is as follow; for example, a LBW child (6 points), with birth interval of less than 3 (4 points), with nutrition style of formula feeding (5 points) has a total score of 15, as probability of being underweight for this child is about 60% (**Figure 1**).

4- DISCUSSION

The current study aimed to estimate the prevalence of malnutrition, identify the determinants of malnutrition, and develop nomograms estimating the probability of malnutrition based on the combination of mother and children characteristics. The results of multivariable analysis showed that underweight may be determined by mother's education, low birth weight (LBW), birth interval, nutrition style, age of introduction of complementary feeding (AUC=0.75); stunting by sex, age, maternal age, father's education, family size, LBW, birth order and nutrition style (AUC=0.67); and wasting by sex, age, mother's education, LBW and nutrition style (AUC=0.72). LBW was the only significant shared determinant for the three malnutrition indices with an odds ratio over than 2.00. Upon our best knowledge, we think this is the first study developing nomograms and internally validating the developed models.

Our results indicated that the prevalence of underweight, stunting and wasting were 7%, 0.20 and 6%, respectively. A meta-analysis in Iran (8) showed that the prevalence of underweight and wasting at the national level was 6% and 4%, respectively. Another meta-analysis (16) suggests the prevalence of stunting among under-five children is 12% in Iran. In another meta-analysis, the overall prevalence of severe underweight, moderate and mild underweight were reported as 1%, 6% and 25%, respectively (17).

A previous study in Zahedan in 2009 (18) showed that the prevalence of underweight, stunting and wasting were 68.6%, 60.1% and 38.4%, respectively. In another study among children under 6 years in the rural areas of Sistan and Baluchestan Province in 2013 (19) the corresponding figures were 19.4%, 32.1% and 9.4%, respectively. Here it could be inferred that the prevalence of malnutrition in this province has decreased during the last years due to marked improvements e.g. in health care services and prevention strategies. The estimated prevalence rates of underweight and stunting were 4.3% and 3.1% in Mashhad, center of Khorasan Razavi province (20). In another study in South Khorasan, Iran, the prevalence of moderate and high underweight and stunting were 12.9% and 16.6%, respectively (21). Results of studies outside Iran, e.g. from high burden areas showed that the prevalence of stunting can be comparable with prevalence of underweighting and these two malnutrition indices are higher than wasting (22, 23).

Our results have demonstrated that the probability of underweight, stunting and wasting among children can be associated with the characteristics of children and parents. A number of previous studies (10, 14) have assessed the determinants of childhood malnutrition but nomograms with the combination of these determinants are lacking. The presently provided nomograms have potential implications for clinicians and health care providers for decision-making as the combination of determinants can improve the discrimination power of underweight, stunting and wasting by 75%, 0.67% and 72%, respectively.

The present analyses demonstrated that, among the studied determinants, LBW was the only shared significant component of nomograms of underweight, stunting and wasting as, the odds of this type of malnutrition among children with LBW was over 2 times more than those born with normal birth weight. These findings are consistent with other studies (10) that reported LBW as an important determinant of malnutrition. For instance, in a study among malnourished children in Qazvin, Iran, the LBW was the only significant risk factor of wasting, stunting and underweight (10). In another study in Bangladesh as a high-risk area, the point estimates for the effect of LBW on three different malnutrition statuses appeared homogeneous at about 1 to 4 at subgroups of confounders (15). Another study also reveals that LBW appears to be an important risk factor of children being malnourished even if their mothers were educated or their household socio-economic conditions were good (15).

The positive relationship between LBW and child malnutrition could be described by several reasons. Increased risk of malnutrition in children with LBW may be due to subsequent infections and complications during infancy (24). Weight and length at birth are known as important predictors of later children's weight and height status as, the risk of growth failure among children with LBW during early childhood are higher and they are more likely to be stunted, underweight or wasted (25).

In the present study, it was observed that the inadequate birth spacing i.e., less than 3 years, was significantly associated with odds of being underweight. Our finding is similar to the previous studies in the African region and South-East Asia as high risk areas (26, 27), however, some studies have suggested that birth intervals lower than 3 years may decrease the risk of underweight (13). It is argued that the optimal birth interval is between 36 and 59 months and the risk of adverse outcomes for the child will be increased when birth intervals reach over 60 months (28). In a meta-analysis by Motedayen et al. (17), the prevalence of underweight, stunting and wasting were higher among children with birth distances lower than 3-year intervals.

Our finding indicated that the children of mothers who were well educated were more likely to be wasted and underweight compared to the illiterate mothers, a finding consistent with other previous studies (15, 29). For example, in a study by Rahman et al. (15) children with LBW whose mothers were educated were at risk for underweight, wasting and stunting; however, some studies suggested that those whose mothers were illiterate were more underweight (30), wasted (31), and stunted (32) compared to those with educated mothers. Moreover, our multivariable analyses have demonstrated that having fathers with diploma degrees is a significant predictive factor for stunting, but not underweight and wasting; however, previous studies have suggested having educated fathers may predict severe acute malnutrition (14) and underweight (33). This is an important question as to why more malnourished children have occurred among educated mothers and whether these mothers cannot provide adequate time and attention to their children. It should be noted that the causal pathway between parental education and malnutrition needs to be explored using more confounders such as mother's occupation, lower health literacy, and cultural factors.

Table-1: Characteristics of the participants and crude odds ratio (95% confidence intervals) of factors determining underweight, stunting and wasting using univariate binary logistic regression analyses

Characteristics		Weight for Age (Underweight)				Height for age (Stunting)				Weight for height (Wasting)			
		Normal	Underweight	OR (95% CI)	P	Normal	Stunted	OR (95% CI)	P	Normal	Wasted	OR (95% CI)	P
Sex	Female	397 (52.10)	27 (43.55)			347 (52.98)	78 (46.15)			405 (52.12)	20 (41.67)		
	Male	365 (47.90)	35 (56.45)	1.40 (0.83, 2.37)	0.20	308 (47.02)	91 (53.85)	1.31 (0.93, 1.84)	0.11	372 (47.88)	28 (58.33)	1.52 (0.84, 2.75)	0.16
Age	< 1 yrs	375 (49.21)	35 (56.45)			335 (51.15)	75 (44.38)			397 (51.09)	13 (27.08)		
	1 – 5 yrs	387 (50.79)	27 (43.55)	0.74 (0.44, 1.25)	0.27	320 (48.85)	94 (55.62)	1.31 (0.93, 1.84)	0.11	380 (48.91)	35 (72.92)	2.81 (1.46, 5.39)	0.002
Maternal age	> 35 yrs	74 (9.71)	4 (6.45)			69 (10.53)	9 (5.33)			72 (9.27)	6 (12.50)		
	18 – 35 yrs	561 (73.62)	45 (72.58)	1.48 (0.51, 4.24)	0.46	485 (74.05)	120 (71.01)	1.89 (0.92, 3.90)	0.08	571 (73.49)	35 (72.95)	0.73 (0.30, 1.80)	0.50
	< 18 yrs	127 (16.67)	13 (20.97)	1.89 (0.60, 6.02)	0.28	101 (15.42)	40 (23.67)	3.03 (1.38, 6.65)	0.006	134 (17.25)	7 (14.58)	0.62 (0.20, 1.93)	0.41
Mother's education	Illiterate	307 (40.29)	20 (32.26)			265 (40.46)	62 (36.69)			306 (39.38)	21 (43.75)		
	Primary education	330 (43.31)	31 (50)	1.42 (0.80, 2.54)	0.22	279 (42.60)	81 (47.93)	1.23 (0.85, 1.79)	0.25	343 (44.14)	18 (37.50)	0.76 (0.40, 1.45)	0.42
	Secondary education	95 (12.47)	10 (16.13)	1.64 (0.75, 3.59)	0.21	83 (12.67)	23 (13.61)	1.19 (0.70, 2.04)	0.51	98 (12.61)	8 (16.67)	1.23 (0.53, 2.80)	0.49
	Diploma	28 (3.67)	0	0.26 (0.01, 4.46) *	0.35	25 (3.82)	3 (1.78)	0.58 (0.18, 1.84)	0.35	28 (3.60)	0	0.25 (0.01, 4.23) *	0.33
	Academic	2 (0.26)	1 (1.61)	8.99 (1.13, 71.53)	0.04	3 (0.46)	0	0.60 (0.03, 11.89) *	0.74	2 (0.26)	1 (2.08)	8.55 (1.07, 67.84)	0.04
Father's Education	Illiterate	159 (20.87)	12 (19.35)			133 (20.31)	38 (22.49)			161 (20.72)	10 (20.83)		
	Primary education	311 (40.81)	27 (43.55)	1.15 (0.56, 2.33)	0.70	266 (40.61)	71 (42.01)	0.93 (0.59, 1.45)	0.76	321 (41.31)	17 (35.42)	0.85 (0.38, 1.90)	0.69
	Secondary education	195 (25.59)	18 (29.03)	1.22 (0.57, 2.61)	0.60	168 (25.65)	46 (27.22)	0.96 (0.58, 1.55)	0.86	200 (25.74)	14 (29.17)	1.12 (0.48. 2.60)	0.78
	Diploma	88 (11.55)	4 (6.45)	0.60 (0.18, 1.92)	0.40	80 (12.21)	12 (7.10)	0.52 (0.26, 1.06)	0.07	86 (11.07)	6 (12.50)	1.12 (0.39, 3.19)	0.82
	Academic	9 (1.18)	1 (1.61)	1.47 (0.17, 12.60)	0.72	8 (1.22)	2 (1.18)	0.87 (0.18, 4.29)	0.87	9 (1.16)	1 (2.08)	1.78 (0.20, 15.56)	0.60
Family size	≤ 5	499 (65.49)	42 (67.74)			410 (62.60)	131 (77.51)			512 (65.89)	30 (62.50)		
	> 5	263 (34.51)	20 (32.26)	0.90 (0.52, 1.57)	0.72	245 (37.40)	38 (22.49)	0.48 (0.32, 0.72)	<0.001	265 (34.11)	18 (37.50)	1.16 (0.63, 2.11)	0.63
Birth weight	> 2500 gr	686 (90.26)	41 (67.21)			593 (90.95)	133 (78.70)			692 (89.29)	35 (74.47)		
	< 2500 gr	74 (9.74)	20 (32.79)	4.52 (2.51, 8.12)	<0.001	59 (9.05)	36 (21.30)	2.72 (1.72, 4.28)	<0.001	83 (10.71)	12 (25.53)	2.85 (1.42, 5.72)	0.003
Birth interval	First birth	214 (28.08)	13 (20.97)			182 (27.79)	45 (26.63)			213 (27.41)	14 (29.17)		
	< 3 yrs	268 (35.17)	35 (56.45)	2.14 (1.10, 4.16)	0.02	238 (36.34)	66 (39.05)	1.12 (0.73, 1.71)	0.59	281 (36.16)	23 (47.92)	1.24 (0.62, 2.47)	0.53
	≥ 3 yrs	280 (36.75)	14 (22.58)	0.82 (0.37, 1.78)	0.62	235 (35.88)	58 (34.32)	0.99 (0.64, 1.54)	0.99	283 (36.42)	11 (22.92)	0.59 (0.26, 1.32)	0.20
Birth order	≤ 3	550 (72.18)	49 (79.03)			462 (70.53)	137 (81.07)			566 (72.84)	34 (70.83)		
	4-6	178 (23.36)	12 (19.35)	0.75 (0.39, 1.45)	0.40	160 (24.43)	30 (17.75)	0.63 (0.41, 0.97)	0.04	179 (23.04)	11 (22.92)	1.02 (0.50, 2.06)	0.94
	≥ 7	34 (4.46)	1 (1.61)	0.33 (0.04, 2.46)	0.28	33 (5.04)	2 (1.18)	0.20 (0.05, 0.86)	0.03	32 (4.12)	3 (6.25)	1.56 (0.45, 5.35)	0.47
Nutrition style	breastfeeding	566 (74.28)	41 (66.13)			490 (74.81)	116 (68.64)			575 (74)	32 (66.67)		
	Formula feeding	29 (3.81)	9 (14.25)	4.28 (1.90, 9.65)	<0.001	31 (4.73)	8 (4.73)	1.09 (0.48, 2.43)	0.83	34 (4.38)	5 (10.42)	2.64 (0.96, 7.21)	0.06
	Both	167 (21.92)	12(19.35)	0.99 (0.51, 1.93)	0.98	134 (20.46)	45 (26.63)	1.41 (0.95, 2.10)	0.08	168 (21.62)	11 (22.92)	1.17 (0.58, 2.38)	0.65
Age of introduction of complementary feeding	> 6 months	285 (37.45)	16 (25.81)			250 (38.23)	51 (30.18)			288 (37.11)	14 (29.17)		
	4 – 6 months	441 (57.95)	40 (64.52)	1.61 (0.88, 2.93)	0.11	374 (57.19)	107 (63.31)	1.40 (0.97, 2.03)	0.07	448 (57.73)	33 (68.75)	1.51 (0.80, 2.88)	0.21
	< 4 months	35 (4.60)	6 (9.68)	3.05 (1.12, 8.31)	0.03	30 (4.59)	11 (6.51)	1.79 (0.84, 3.81)	0.12	40 (5.15)	1 (2.08)	0.51 (0.06, 4.01)	0.52

* estimated using firth bias adjustment

Table-2: Adjusted odds ratio (95% confidence intervals) of factors determining underweight, stunting and wasting using multivariable binary logistic regression analyses

Characteristics	Original model	p	Bootstrapped model
Weight for Age (Underweight)			
Mother's education			
Illiterate			
Academic	14.73 (1.26, 172.27)	0.03	14.73 (3.54, 61.19)
Birth weight			
≥ 2500 gr			
< 2500 gr	4.87 (2.63, 9.01)	<0.001	4.87 (2.55, 9.29)
Birth interval			
First birth			
< 3 yrs	2.93 (1.67, 5.13)	<0.001	2.93 (1.66, 5.16)
Nutrition style			
Breastfeeding			
Formula feeding	3.92 (1.67, 9.20)	0.002	3.92 (1.55, 9.96)
Age of introduction of complementary feeding			
> 6 months			
4 – 6 months	1.39 (0.74, 2.60)	0.29	1.39 (0.75, 2.59)
< 4 months	2.05 (0.69, 6.11)	0.19	2.05 (0.68, 6.19)
Height for Age (Stunting)			
Sex			
Female			
Male	1.20 (0.84, 1.72)	0.30	1.20 (0.82, 1.75)
Age			
< 1 yrs			
2 – 5 yrs	1.56 (1.09, 2.24)	0.01	1.56 (1.09, 2.23)
Maternal age			
> 35 yrs			
18 – 35 yrs	1.48 (0.67, 3.25)	0.32	1.48 (0.61, 3.57)
< 18 yrs	1.77 (0.74, 4.24)	0.20	1.77 (0.66, 4.71)
Father's Education			
Illiterate			
Diploma	0.40 (0.21, 0.79)	0.009	0.40 (0.18, 0.89)
Family size			
≤ 5			
> 5	0.35 (0.15, 0.83)	0.02	0.35 (0.14, 0.89)
Birth weight			
≥ 2500 gr			
< 2500 gr	2.65 (1.63, 4.33)	<0.001	2.65 (1.57, 4.47)
Birth order			
≤ 3			
4-6	1.83 (0.73, 4.58)	0.19	1.83 (0.69, 4.87)
≥ 7	0.72 (0.13, 4.02)	0.71	0.72 (0.14, 3.66)
Nutrition style			

Characteristics	Original model	p	Bootstrapped model
Breastfeeding			
Both	1.45 (0.96, 2.20)	0.07	1.45 (0.95, 2.23)
Age of introduction of complementary feeding			
> 6 months			
4 – 6 months	1.42 (0.96, 2.09)	0.07	1.42 (0.95, 2.12)
< 4 months	1.49 (0.68, 3.27)	0.31	1.49 (0.63, 3.53)
Weight for Height (Wasting)			
Sex			
Female			
Male	1.66 (0.90, 3.08)	0.10	1.66 (0.91 3.06)
Age			
< 1 yrs			
2 – 5 yrs	3.11 (1.57, 6.15)	0.001	3.11 (1.49 6.48)
Mather's Education			
Illiterate			
Academic	24.45 (2.00, 298, 21)	0.01	24.45 (4.63, 129.44)
Birth weight			
≥ 2500 gr			
< 2500 gr	3.18 (1.55, 6.52)	0.002	3.18 (1.40, 7.05)
Nutrition style			
Breastfeeding			
Formula feeding	2.40 (0.87, 6.65)	0.09	2.40 (0.74, 7.79)

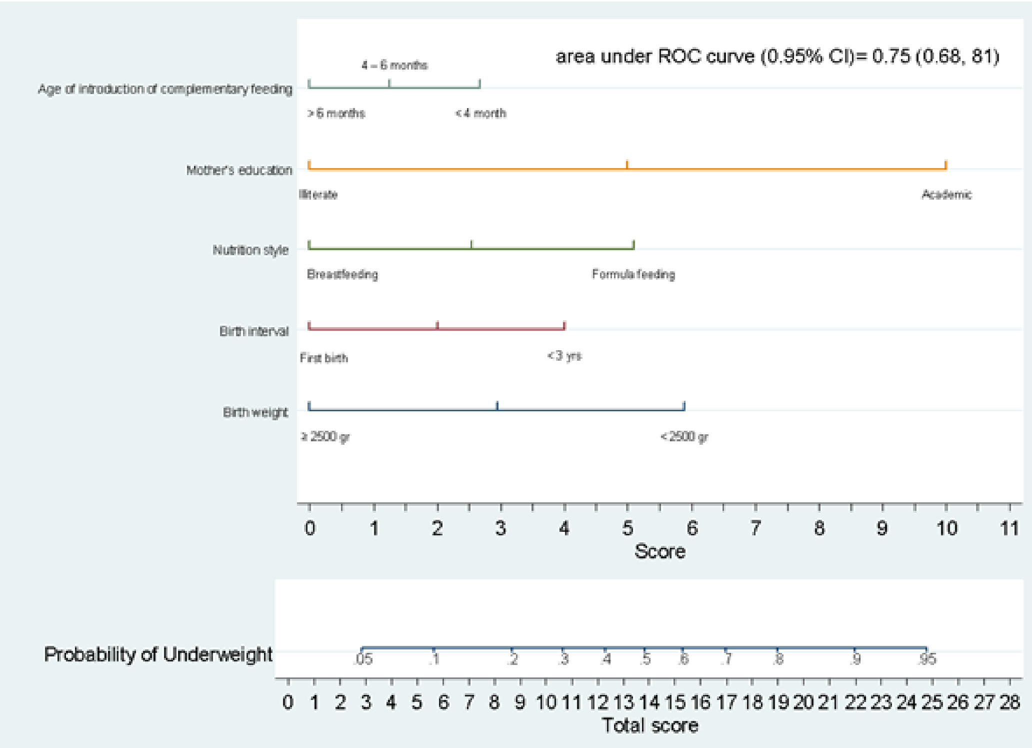

Fig. 1: Nomogram estimating probability of underweight using the factors included in multivariable analyses after bootstrapping

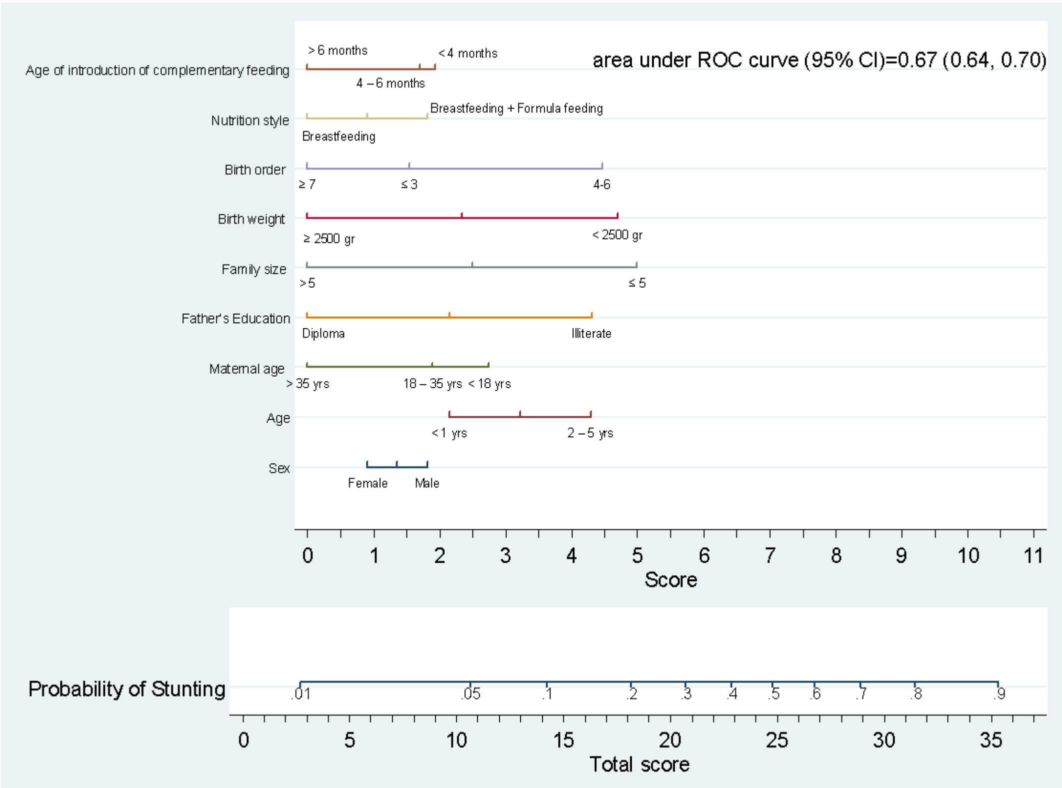

Fig. 2: Nomogram estimating probability of stunting using the factors included in multivariable analyses after bootstrapping

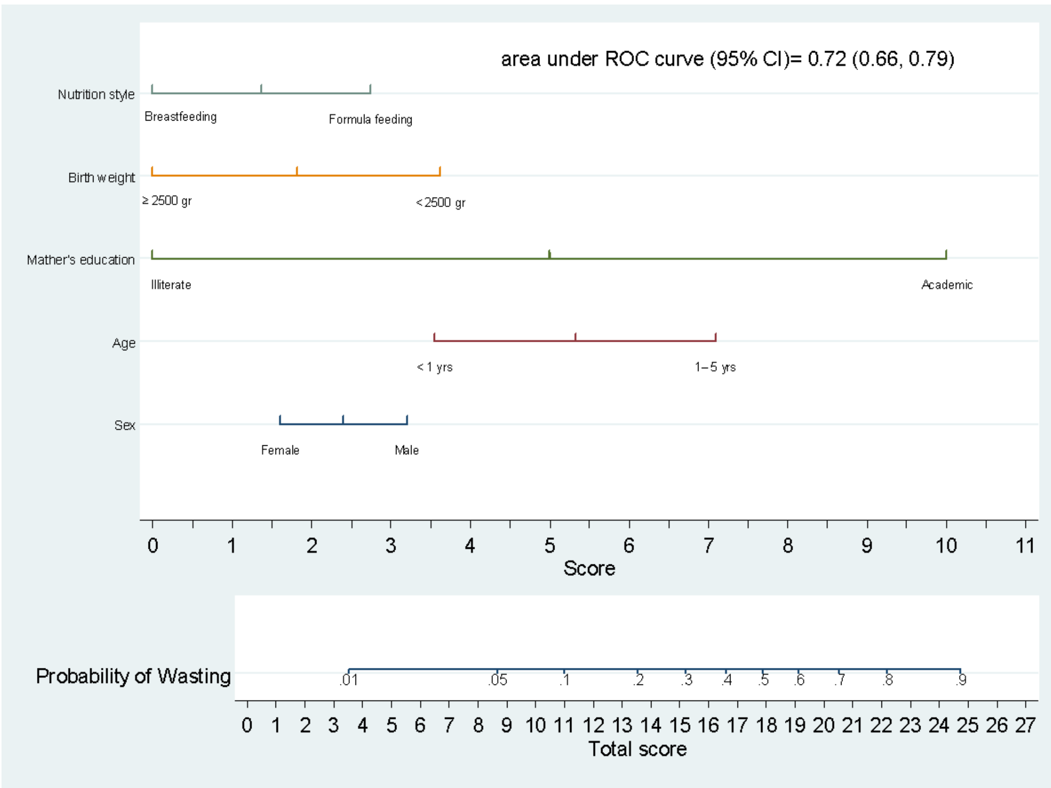

Fig. 3: Nomogram estimating probability of wasting using the factors included in multivariable analyses after bootstrapping

Consistent with previous studies (34), our results have demonstrated that the children's consumption of formula and complementary food within the first six months were important factors in increasing odds of malnutrition. Exclusive breastfeeding for the first six months and appropriate complementary feeding are known as important factors in the integrated management of childhood illness (IMCI) approach to child health which is also recommended by World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF) (35). The results from a study by Shafieian et al. (20) have emphasized the role of average daily consumption of milk, feeding practices and the type of first food on nutritional status.

5- CONCLUSION

In conclusion, the prevalence of underweight, stunting and wasting were 7.6%, 20.6% and 5.8%, respectively (8.8%, 23% and 7% for boys and 6.6%, 18.4% and 4.7% for girls, respectively). Although the estimated prevalence rates were lower than those estimated from previous studies in Zahedan, they are still higher than the national average. According to the results of multivariable analysis, underweight may be determined by the mother's educational level, low birth weight (LBW), birth interval, nutrition style, age of introduction of complementary feeding (AUC=0.75); stunting by sex, age, maternal age, father's education, family size, LBW, birth order and nutrition style (AUC=0.67) and wasting by sex, age, mother's education, LBW and nutrition style (AUC=0.72). LBW was the only significant shared determinant in the nomograms with an odds ratio of over 2.00. The identified determinants from the multivariable analysis can be used to develop nomograms for estimating the probability of malnutrition, and these identified determinants can be targeted for the development of nutritional and educational strategies.

6- LIMITATIONS OF THE STUDY

Findings of the present study need to be interpreted with caution; the links provided between the risk factors and malnutrition in a single cross-sectional study might be temporal. Our results may depend on the validity of the registered data. The risk of exposed misclassification should be also considered, because in some cases, that information could not be extracted from the records, the information was gathered through interviews with the child's mother. The developed final models were validated through bootstrapping; however, such a model still requires to be validated based on external validation. The true effect of the studied determinants and discrimination power of nomograms may be different from that observed in the study because some relevant risk factors such as economic status, accessibility to food, parent's occupation, household characteristics, number of siblings, place of birth, etc., were not studied. The malnutrition indices might not be mutually exclusive, e.g. a child could have both underweight and stunting and the effect of determinants of underweight may be confounded with stunting. Furthermore, the risk of selection bias in the estimates should be considered and finally, considering dichotomous determinants may imply loss of information.

7- ETHICAL CONSIDERATIONS

This study complied with the Declaration of Helsinki and was approved by the Ethics Committee of the Zahedan University of Medical Sciences (ZAUMS). The present study is registered with an ID code of 1734 at ZAUMS. In addition, Informed consent was obtained from mothers and they were informed voluntarily to participate as well as anonymously and confidentiality of information.

8- ACKNOWLEDGMENTS

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