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Statistical modeling for the determinants of stunting in children under-five year of age in Pakistan

[1] Zafar Mahmood, [2] Syed Muhammad Asim, [3] Mashal, [*4] Nadar Khan, [5] Ejaz Ali Khan, [6] Nadeem Khan
[1] Department of Maths, Stats & C.Sc., The University of Agriculture Peshawar, Pakistan
[2, 3] Department of Statistics, University of Peshawar, Pakistan
[4] Department of Animal Nutrition, The University of Agriculture Peshawar, Pakistan
[5] Institute of Nursing Science, Khyber Medical University Peshawar, Pakistan
[6] Department of Social Sciences, University of Peshawar, Pakistan

Abstract
The aim of the study was to evaluate the problem of stunting and associated risk factor of stunting in Pakistan and explore significant factors of stunting using robust estimates of regression parameters. We conducted secondary data analysis taken from Pakistan Demographic and Health Survey (PDHS) 2013. Eleven thousand and seven hundred children of under-five year of age. Multiple linear regression analysis with robust standard error were used for assessing the relationship between stunting and selected variables like region (provinces), areas (rural and urban), breast feeding, age of mother, and socio economic status. Variance inflation factors (VIF) and white's test were used for testing multi collinearity and homo scedasticty before fitting the regression model. The study explored that significant factors that affect stunting are mother's education, breastfeeding, and region. It is concluded that problem of stunting is significantly different over regions (provinces) and areas. In urban areas, the regions as well as mother's education were significant factors. Whereas, regions and months of breastfeeding greatly effecting the prevalence of stunting in rural areas. The major factors that are associated with stunting were duration of breast feeding, mother's education and regions in Pakistan. Our findings give a baseline for concerns and assessment with future studies.

Keywords: child nutrition, stunting, robust models, multi collinearity, heteroscedasticity

Introduction

Child under-nutrition is a worldwide burden. Habicht found that more than 1 billion people are under-nourished [1] while UNICEF reported that under-nutrition contributes to more than 30% of all deaths in children below five years [2]. Under-nutrition includes being underweight (low weight for age), stunted (low height for age), and wasted (low weight for height). The causes of under-nutrition are multiple including inadequate dietary intake and diseases, food insecurity, inadequate care, unhealthy environment and inadequate health services [2-3]. These days the problem of stunting used is indicator of child under-nutrition is very common in developing and under developing countries. Stunting is the constant restraint of child's prospective growth. It reflects long-standing effects of insufficient nutrition and a disreputable disease environment at an early age of life. It is the most common form of under-nutrition for children in the developing world and women tendency is to be more affected than men [4]. Low height-for-age is referred to as stunting and occurs when the Z-score is below the median by more than -2SD [5-7]. Stunting is seen as a failure to reach linear growth and is prevalent in children with long-term insufficient nutrient intake and frequent infections. If a child is stunted before the age of two years, then irreversible effects of poor motor and cognitive development occur. The prevalence of stunting occurs amongst one-third of the world‟s children [2, 3, 5]. Black *et al*. reported that the prevalence of stunting stood at 32% for children younger than 5 years old in developing countries. In the literature it was reported that South Asia perhaps suffers from the highest absolute numbers of stunted children [8]. Stunting occurs generally in children aged between 0-24 months, particularly during weaning periods.

Growth faltering is also heavily influenced by the early infection disease environment and its incidence increases progressively from birth and stabilizes after two years of life. Young & Jaspers explored that prevalence is higher for older children as compared to younger ones because of some environmental effects [9]. Due to its dependence on past disease environment and nutritional conditions, height is widely used as a proxy measure of poverty and socio economic conditions at a certain point in time [10, 11]. Regardless what causes stunting at early ages, stunted people tend to perform worse in education, work and health than their taller counterparts in later stages of life. Estimate indicates that in 2005, approximately 178 million children under-five year of age in low- and middle-income countries were stunted [12]. The demographic and health survey in Pakistan (2012-13) showed that about 45% children under-five year of age were stunted in which 37% in urban and 48% in rural were severely stunted. According to the World Health Organisation (WHO) the children considered too less for their age when "height for age" value is to be less than minus two standard deviations (-2SD) from the WHO Child Growth Standards median of the reference population(7). Stunting means height for age. It can also be used as a measure of nutritional status of children (under five year of age) and refers to that whatever happens to a child's brain and body when they don't get the right kind of food or nutrients in early ages. A stunted child will never learn, nor earn as much as compare to un-stunted child. Stunting refers failure to reach linear growth potential due to bad nutrition and poor health [13-15]. Further a stunted child height is some inches shorter then height of un-stunted child. So it is necessary that a child need a proper food, clean water, education etc in early ages. In other words a study of stunting shows the proportion of those Childs, who's weight are less as much required for their current ages due to less proper foods or nutrients. Stunting is the most serious problem of the country. Its effects family and country economic condition, social condition etc. and similarly a bad nutrition not only affect the child's current health condition as well as affect individual and national future development. Malnutrition increases the chance of disease and death. Stunting problem more often arises at about six months of age when children shifting from breast milk to complementary poor quality foods [14]. Consequences of stunting includes poor school performance and increasing the chance of morbidity and mortality. Moreover, stunted child before the age of two have been shown to have poorer emotional and behaviour outcomes in later ages. As stunting leads to reduction in children size, so it is also affected to reduce work capacity [16]. Across Pakistan, there are 43.7% child's under-five were stunted in 2011 as compared to 41.6% in 2001 (National Nutrition Survey, 2011). The stunting rates: 70.5% in 1977; 62.5% in 1985-87; 42.7% in 1990-94, 54.5% in1990-91 and 41.5% in 2001 in Pakistan [17].

A lot of work has been done in most of the countries of the world regarding the problem of stunting. Rayhan & Khan conducted the study based on the problem of stunting and their analysis revealed that 48% children were stunted. Bivariate and multivariate models were used to measure the determinant of children under-five malnutrition. The significant factors were found to be previous birth interval, size at birth, mother's body mass index at birth and parent's education [18]. Teshome *et al*. investigated the phenomena of stunting. They found that 43.2% of the children under-five year were suffering from chronic malnutrition and 49.2% under-weight. The significant factors for stunting were sex of the child, child age, duration of Breastfeeding, types of food, age of introduction of complementary feeding and method of feeding [19]. Som *et al*. studied the problem of stunting in three States of India. The three states were Behar, west Bangal and Karela. They used Regression Analysis and chi-squire test. The study resulted that the percentage of Stunting in Behar, West Bangal and Karela was 54%, 39% and 23% respectively. The significant factors were women education and house hold Condition Index. Further the study concluded that months of breastfeeding and birth order shows association with the health status of children under five [20]. Taguri *et al*. studied risk factors of stunting among children of under-five in Libya. The purpose of this study was to measure different predictor's of stunting in children of age less than 5 year. They applied logistic regression with bivariate and multivariate analysis techniques. The study investigated 4498 children's. The result shown that 929 children were stunted (20.7%) in which 434 were girls (46.5%) and 495 were boys (53%). In multivariate analysis the factors were young age<2, having less educated fathers, throwing garbage in street, being a boy, filtered water, father never/rarely play with child and low birth weight [21]. Kravdal & Kodzi conducted a study to examine the effect of high fertility on stunting using DHS data consisting of 145,000 children. Using regression models they concluded that high fertility has no significant impact on child's stunting [22]. Onis *et al*. measured the prevalence of stunting in Switzerland using the data from the year 1990-2010. Linear mixed effect modelling was used in study. They concluded that number of stunted child under-five ages were 171 Million in Switzerland. Further the study concluded that the prevalence of stunted child's under-five decreased from 39.7% in 1990 to 26.7% in 2010. They forecasted that the trend of stunting to be 21.8% or 142 million in 2020 [23]. Darteh *et al*. conducted the study on phenomena of stunting (in Ghana). The basic aim of the study was correlates of stunting among children in Ghana using data from the 2008 Ghana Demographic and Health Survey (GDHS). Multivariate and Bivariate statistics were used. The analysis shows that proportion of stunting was 27.5%. The problem of stunting was more likely to rise in those household having 5-8 children as compared having 1-4 children. Similarly the age was also significant predictor [24]. In South Africa, during 2003 stunting was found to be higher in rural areas, with a prevalence of 28.1 percent, in comparison with 26.9 percent in urban areas [25]. They reported that the stunting was prevalent in 38.4 percent of children where the mother had no education and also more prevalent amongst children where the mothers were between the ages of 45 and 59, and of Black and Colored race. The survey in 2005 compared to that of 1999, found that stunting decreased to 23.4 percent amongst children aged one to three years, 66.4 percent amongst children aged four to six years and 12 percent amongst children aged seven to nine years [26]. Stunting has been regarded as a leader in nutritional disorders, with one in five children affected internationally. Table 1.4 reflects that 33 percent of the world‟s children are moderately stunted and 17 percent severely stunted [2].

Material and Methods

The base of the data for this study is Pakistan Demographic & Health Survey 2012-13 to undock the model for stunting. Demographic and health survey (DHS) is representative national household surveys and established by the United States Agency for International Development (USAID) in 1984 and responsible for collecting, analysing and disseminating accurate data on population, fertility, family planning, maternal and child health, gender, HIV/AIDS, malaria, and nutrition. The software used in this study is STATA 12. The statistical technique multiple regression model with robust standard error estimates was used along with testing assumption by appropriate statistical tests before fitting the final model.

The analytical technique and model assumption checks

Simple linear regression model for each individual explanatory variable is often inadequate in most real situations when response variable is effected by several explanatory variables. A regression model which involves two or more explanatory variables is called multiple regression models. In another words regression models in which change in response variable is explained by two or more explanatory variable (or independent variables) is called multiple regression model. General form of multiple regression models which involve k-independent variables is:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \cdots \beta_k X_{ki} + \varepsilon_i \; for \; i = 1,2,3 \dots n$$

Where ε_i called random error, which represents all those variables which are not included in the model. Y_i is the response variable and assumed as a random variable. $X_i's$ Are explanatory variables which are treated as fixed and β_0 & $\beta_i's$ are the population parameters. Further β_0 called intercept and it is mean value of Y when all $X_i's$ are zero. The coefficients $\beta_1, \beta_2, \beta_3, \dots . \beta_k$ called partial regression coefficient. The partial regression coefficient can be interpreted as follows:

β_1 Shows change in mean value of Y, per unit change in X_1, keeping other predictors constant. β_2 Measures change in mean value of Y for unit change in X_2, keeping the values of all other explanatory variables constant. Similarly β_3 shows change in mean value of Y for unit change in X_3, holding all remaining variables constant. And so on.

Before fitting the model we must check its assumptions particularly we have checked the model for Multicollinearity and Hetroscedasticty [27, 28].

Multicollinearity refers to existence of perfect or high linear relationship (or correlation) between some or all explanatory variables included in the model. One of the assumption of Classical Linear Regression Model (CLRM) is that no correlation or linear relationship among regressors. Mathematically,

$$corr(x_i, x_j) = 0 \; for \; i \neq j$$

And if there is case of multicollinearity then

$$corr(x_i, x_j) \neq 0 \; for \; i \neq j$$

Various techniques are used for detection of multicollinearity in which one of them is Variance inflation factor (VIF). VIF represent the factor by which the variance of OLS estimator is increase in the presence of multicollinearity. More specifically VIF measure how much the variance of estimated coefficients increases in the presence of multicollinearity over the case of no multicollinearity. If there is no correlation between regressors, then all VIFs will be one. Its mathematical function is given by:

$$\frac{1}{1 - R_i^2}$$

Where R_i^2 is auxiliary R^2 and can be obtained from regressing X_i on the rest of regressors.

The phenomena of hetroscedasticty deal with variances of disturbance term u_i. One of the assumptions of classical linear regression model is that variance of each disturbance term u_i, conditional chosen value of explanatory variable X_i is constant number equal to σ^2. This is called homoscedasticty, symbolically:

$$var(u_i) = E\left(\frac{u_i^2}{X_i}\right) = \sigma^2 for \; i = 1,2,3 \dots n$$

On other hand if variances of u_i not same then it is called hetroscedasticty, symbolically

$$var(u_i) = E\left(\frac{u_i^2}{X_i}\right) \neq \sigma^2 for \; i = 1,2,3 \dots n$$

Like multicollinearity, various procedures are used for detecting hetroscedasticty in which one of them is white's hetroscedasticty test. The test is used for detecting the problem of Hetroscedasticty. The hypothesis can be tested in this test is the variance of error term is homoscedastic, which negation is the alternative hypothesis. The test is established by Whites and one of the advantages of the test is that it does not rely on the normality assumption. Further the test utilised chi-square test statistic, that is:

$$n. R^2 \sim \chi^2(df)$$

Where degrees of freedom equal to number of regression coefficient excluding intercept in the auxiliary regression and R^2 can be measure from regressing the below model:

$$\hat{u_i} = \gamma_0 + \gamma_1 X_{1i} + \gamma_2 X_{2i} + \gamma_3 X_{1i}^2 + \gamma_4 X_{2i}^2 + \gamma_5 X_{1i} X_{2i} + v_i$$

Where $\hat{u_i}$ are estimated residuals, which can be obtained from original model (regressing y on x) ignoring hetroscedasticty. The logic for testing the constant variance, one assumes an auxiliary regression model and regresses the squared residuals from the original regression model onto a set of explanatory variables which contain the original explanatory variables along with their squares and cross products

Results and Discussion

Before running multiple linear regression models, the model assumptions were tested for multicollinearity and hetroscedasticty. As mentioned earlier we used Variance Inflation Factor (VIF) as a Test for Multicollinearity. Using STATA version 12 we obtained the following results given in Table 2.

By looking in Table-2 we seen that the VIF is less than 10 for all the variables, so by rule of thumb we conclude that there is No Multicollinearity in the explanatory variables of the current study. We used Whites Test for detecting hetroscedasticty. White test is basically a widely used statistical test that set up to check in a regression model whether the error variance of a variable is homoscedastic. This test was proposed by Halbert White in 1980. Using STATA version 12, we obtained the following results given in Table 3. Table 3 gives very large value of Chi-square statistic and also very small p- value for testing Hetroscedasticty. So we conclude that there is a serious case of Hetroscedasticty in the current study. Now we will use Whites Suggestions (robust standard errors) as a remedial measure for the problem of Hetroscedasticty.

Multiple regression model with robust standard error (Over all Model)

As mentioned earlier while using dummy variable approach for categorical variables, the base category or bench mark category for variables Region, Types of place of residence, Wealth index, Sex of the child, Size of child at birth and Mother's education are taken as urban, Punjab, Poor, Male, Large and No education respectively. The following results were obtained for the overall regression model by taking all the variables of interest into consideration with robust standard errors. The Table. 4 shows stunting in Sindh, Khyber Pakhtunkhwa, Baluchistan and Gilgit Baltistan are significantly more, on the average than stunting in Punjab. The result shows only insignificant difference between stunting in Islamabad and stunting in Punjab, Thus stunting significantly different over Region. Stunting in rural area are more, on the average, then stunting in urban but the difference is not statistically significant. The analysis shows stunting in those children's who belongs to poorer, middle, richer and richest family is not significantly differ from stunting in those children who belongs to poor family. More specifically, no effect of wealth index on stunting. The result shows no significant difference between stunting in female children and stunting in male children. Further we see that the problem of stunting in female children is less as compare to male children. The problem of stunting in those children who size is average and small are not significantly more than whom size is large at birth, thus no effect of size of child at birth on stunting. There is no significant effect of mother's education on stunting that is stunting in those children who mother's have primary, middle, secondary and higher education is insignificantly different from stunting in those children who mother's are un-educated. The result shows insignificant results for variables Women's age and Birth order number. The analysis shows that there is significant effect of breast feeding on stunting. We fitted separate multiple regression model for urban and rural considering are-wise stratification. Looking at the Table 4 the result shows stunting in Sindh, Khyber Pakhtunkhwa, Baluchistan and Gilgit Baltistan is significantly different from stunting in Punjab. The result shows insignificant results for stunting in Islamabad and Punjab. We seen there are insignificant difference between stunting in female children and stunting in male children. The factor wealth index shows no impact in stunting that is each category that is poorer, middle, richer and richest children are not significantly different from bench mark category (which is poor children) for stunting. Stunting in those entire children who size are average and small are not significantly different from stunting in those children who size are large at birth. The variable Mother's education shows that stunting in those children who mothers have primary education are significantly different from stunting in those children who mothers are un-educated in urban. Further the result shows that stunting in those children who mothers has middle, secondary and higher education is not significantly different from stunting in those who mothers are uneducated. The result shows insignificant effect of Birth order number and women age on stunting. Similarly the result shows slightly insignificant effect for months of breastfeeding on stunting in urban and the sign of coefficient shows inverse relationship with the problem of stunting.

The Table 5 gives almost same result for variable Region that is stunting in region Sindh, Khyber Pakhtunkhwa, Baluchistan and Gilgit Baltistan is significantly different from stunting in Punjab. The result shows only insignificant difference between stunting in Islamabad and stunting in Punjab. The factor Wealth index gives again no significant effect that is stunting in poorer, middle, richer and richest family children is not significantly different from stunting in poor family children in rural. Once again we seen that no significant difference between stunting in female children and stunting in male children. Birth order number and Women's age no significant effect on stunting in rural area of these two variables. There is significant effect of Months of breastfeeding on stunting. Stunting in those children who mother's have primary, middle, secondary and higher education is not significantly different from stunting in those children who's mother's are un-educated (in rural).

Table 1: Stunting prevalence (2000-2007) (UNICEF 2009) Moderate and severe (%)

Region	Moderate (%)	Severe (%)
Sub-Saharan Africa	38	18
Eastern and Southern Africa	41	18
West and Central Africa	36	18
Middle East and North Africa	25	12
South Asia	46	22
East Asia and Pacific	16	-
Latin America and Caribbean	16	-
CEE/CIS	12	3
Developing countries	32	18
Least developed countries	42	19
World	31	17

Table 2: Variance Inflation Factor (VIF)

Variable	VIF	1/VIF	Variable	VIF	1/VIF
1)Region Base Category(Punjab)	-	-	6)Mother's Education	-	-
Sindh	1.49	0.670662	Base Category (No Education)		
KPK	1.40	0.713664	Primary	1.25	0.8000
Balochistan	1.50	0.668161	Middle	1.22	0.8196
Gilgit Baltistan	1.40	0.719004	Secondary	1.44	0.6944
Islamabad	1.24	0.807338	Higher	1.70	0.5882
2)Types of place of residence Base Category(Urban)	-	-	7) Women's age in year	2.17	0.4608

Rural	1.55	0.645659			
3)Wealth Index Base Category (Poor)	-	-	8)Birth order number	2.34	0.4273
Poorer	1.67	0.598272			
Middle	1.84	0.542450			
Richer	2.42	0.412666			
Richest	3.26	0.306642			
4. Sex of the child Base Category (Male)	-	-	9)Months of Breastfeeding	1.05	0.9523
Female	1.01	0.993996			
5)Size of child at birth Base Category (Large)	-	-	Mean VIF	1.80	0.5555
Average	2.99	0.33405			
Small	3.02	0.331031			

Table 3: Whites General Hetroscedasticty test

Chi-Squire(χ^2)	p-value
840.33	0.0000

Table 4: Multiple Regression Model (Over all Model)

Stunting	Coef.	Robust Standard Error	t-value	P-value	[95% Confidence Interval
1) Region Base Category(Punjab)					
Sindh	7.199932	1.389997	5.10	0.000	4.35468, 9.925182
K*PK*	18.82202	1.697529	11.09	0.000	15.49382, 22.15022
Balochistan	43.56466	2.372091	18.37	0.000	38.9139, 47.21542
Gilgit Baltistan	8.090425	1.947532	3.50	0.000	2.972062,1 0.90879
Islamabad	1.69304	1.629121	1.02	0.299	-1.50104, 4.887122
2)Types of place of residence Base Category(Urban) Rural	0.934332	1.419271	0.66	0.510	-1.84802, 3.712268
3)Wealth Index Base Category (Poor)					
Poorer	0.987053	2.003619	0.49	0.6220	2.94127, 4.925383
Middle	-.002310	2.173065	-.00	0.991	-4.26844, 4.2653
Richer	-.974532	2.309928	-0.43	0.67	-5.14381, 3.534745
Richest	.504254	2.784874	0.18	0.85	-4.96752, 5.962613
4. Sex of the child Base Category (Male) Female	-.565080	1.141543	-0.50	0.537	-2.80320, 1.673048
5)Size of child at birth Base Category (Large)					
Average	1.876594	1.949672	0.97	0.330	-0.9359, 5.69917
Small	4.2912	2.327295	1.85	0.0650	-0.26481, 8.84672
6)Mother's Education Base Category (No Education)					
Primary	-2.90353	1.669194	-1.74	0.082	-6.17618, 0.3691102
Middle	-0.87185	2.197895	-0.40	0.69	-5.37108, 3.447373
Secondary	-3.22551	2.039605	-1.53	0.124	-7.22440, 0.8733639
Higher	1.674733	2.318012	0.72	0.476	-2.8999, 6.21465
7) Women's age in year	-.100929	.1338368	-0.79	0.431	-0.363331, 0.1514736
8)Birth order number	-.284158	.369757	-0.82	0.424	-0.999932, 0.411616
9)Months of Breastfeeding	-.047051	.015012	-2.94	0.003	-0.078444, -.015657
Constant	7.544403	4.132163	1.83	0.064	-0.590, 15.20784

Table 5: Multiple Regressions Model for Rural

Stunting	Coef.	Robust Standard Error	t-value	P-value	[95% Confidence Interval
1) Region Base Category(Punjab)					
Sindh	4.943238	2.015971	2.41	0.016	.896925, 8.896784
K*PK*	19.71491	2.19108	9.09	0.000	15.41796, 23.99186
Balochistan	46.07294	3.266554	14.26	0.000	40.66686, 53.47902
Gilgit Baltistan	6.619589	2.752654	2.4	0.017	1.201715, 12.23746
Islamabad	5.751352	3.276784	1.76	0.079	-.662621, 12.03966
2)Sex of the child Base Category (Male) Female	-.420280	1.527187	-0.28	0.789	-3.42526, 2.564705
3)Wealth Index Base Category (Poor)					
Poorer	-1.08894	2.223014	-0.49	0.624	-5.17347, 3.275686
Middle	.7693	2.602404	0.291	0.769	-4.02601, 5.86199
Richer	-5.35297	2.802757	-1.94	0.053	-10.8494, .073551
Richest	-3.10995	4.443127	-0.70	0.486	-11.0834, 5.623521
4)Size of child at birth Base Category (Large)					
Average	-.987734	2.8013	-0.35	0.727	-6.47017, 4.5245

Small	1.54155	3.202172	0.48	0.63	-4.74037, 7.82207
5)Mother's Education Base Category (No Education)					
Primary	.04981148	2.208707	0.02	0.982	-4.28340, 4.669636
Middle	3.13979	3.175371	0.99	0.323	-3.51328, 9.351239
Secondary	-2.73139	2.840672	-0.98	0.334	-8.36227, 2.8279481
Higher	-2.4564	3.480666	-0.76	0.483	-9.47161, 4.380335
6) Women's age in year	-.022489	.1765874	-0.12	0.90	-.379797, .3128179
7)Birth order number	-.26877	.4648718	-0.56	0.574	-1.17254, .6570788
8)Months of Breastfeeding	-.052760	.0207207	-2.55	0.011	-.093396, -.012125
Constant	9.96469	5.221925	1.79	0.074	-.8965, 19.277197

Conclusion

The study utilised data from Pakistan Demographic and Health Survey 2012-13 for the problem of stunting. Multiple linear regression models with robust standard error were used. By testing assumption, the analysis shown no multicollinearity but there was a serious case of hetroscedasticty, so we used robust standard error as remedial measure for the problem of hetroscedasticty. Multiple regression models were fitted for over all Pakistan, the result shown that the variable Region and Months of breastfeeding were significant factors of stunting. Further the analysis shows that the remaining variables, which are Types of place of residence, Wealth index, Sex of the child, Mother's education, Women age, Size of child at birth and Birth order number has no significant impact on stunting. The model fitted separately for urban and rural. In urban area, the significant factors of stunting were Region and Mother's education. Further the remaining variables shows no significant effect on stunting while considering urban area only. Similarly in rural area, the variable region and months of breast feeding were significant factors of stunting. To control the problem of stunting in Pakistan, keeping in view the above mentioned analyses it is suggested that the duration of breastfeeding might be increased, the level of Mother's education should be improved and the State must grant equal importance to the child health all around the urban and rural region.

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