Logistic Modelling On Maternal And Child Health: A Case Study Of Punjab Districts

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Abstract
Background: utilization of adequate maternal health services is a crucial determinant for healthy motherhood and new infant. There are umpteen number of factors that work behind maternal and child healthcare such as antenatal care, postnatal care, healthy nutrition & diet, income status and social factors. Methods: To investigate the impact of such factors, a cross sectional study was performed in sample villages of Barnala and Sangrur (High Priority Districts) of Punjab. The sample of 620 female respondents were interviewed for examining the maternal and child health status, which further analyzed through Multinominal Logistic Regression. Results: The model revealed that maternal care, mother's qualification, wealth status, childcare and intake of diet were found significant and influenced the health of their newborn. Although massive, strategic investments are persistently made under the national health programmes, but there is need of holistic care toward women and child for sustainable development.

Keywords: maternal health, child health, antenatal care, odds ratio and logistic regression

Background

A number of years elucidate the research on relationship between maternal health and child health. It is widely proved through many empirical studies that good maternal health is a major source of healthy development of child and for whole nation. According to World Health Organization, maternal health refers to the health of women before & during pregnancy, at childbirth and during the postpartum period. Fertility, maternal health and healthy infant purely depend upon the parent's economic and health status. In other words, the health status of a woman is one of the crucial aspects to assess the quality of life of child. Umpteen number of indicators such as antenatal care, institutional delivery and post-natal care determine the maternal health that affect child health definitely at later stage.

High quality antenatal care throughout pregnancy is essential to monitor maternal, perinatal and newborn health, also providing education on health care to expectant parents (WHO, Europe). During pregnancy, the women who remain healthy have more chance to remain healthy after delivery of child.

As per the NFHS report, antenatal care refers to pregnancy related healthcare that is provided by a doctor, a skilled health professional or an ANM. The foremost objective behind the antenatal care is to promote and ensure health of the mother during this crucial period and risk free delivery of the child. Aside this, with the help of antenatal checkup prior health problems can also be detected that not only reduce the risk of maternal mortality but also ensure the reduction of infant mortality and still live births. On the basis of Multinominal Logistic Regression models, various empirical studies, such as Adewara et al (2014), Arfico AH (2019), Gideon Rutaremwa et al (2015) and Mamadou Samba et al (2020) revealed that antenatal care highly depend upon socio and demographic factors like wealth status, education level , place of residence and assistance during delivery. Moreover, Mira Johri et al (2015) investigated the association

between maternal health literacy and child vaccination and reported that mother's education is significant variable to predict the child vaccination outcome.

Asides that, the purpose of the study is to outline the impact of maternal health on child health. To show the inter linkage, the study has been divided under four heads. The major objectives of the study are to explore the effect of socio-economic determinants on child health. and to analyze the impact of maternal health indicators on child health

Material and methods

Study population and sampling framework

A cross sectional study has been conducted in the Punjab state to evaluate the effects of socio economic determinants and maternal health determinants on child health. A list of forty-seven villages of two sample districts (Barnala and Sangrur) was taken and research questions were investigated from 620 households through face-to-face interview method. Additionally, these above stated districts Barnala (Low populated) and Sangrur (High populated) were picked from High Priority District List, disclosed by NITI Aayog in 2015. The list of High Priority Districts of India was prepared to analyze the existing gaps in health sector particularly in maternal and child health.

The stratified sampling technique had been used for identifying the households under which districts and villages have been chosen on the basis of population parameter. Primary data is accumulated from 620 respondents in Sangrur (High Populated) and Barnala (Low Populated) districts as shown in table 1. All the women who were interviewed for the study were around the age of 15-49 years old and belonged to rural area.

Table 1: Distribution of Sample Households across Districts

Sample Districts	Sample Villages*	Sample Households**
Sangrur (High populated)	39	475
Barnala (Low populated)	8	145
Total	47	620

Note: -*5% Villages chosen from all community development blocks
** 5% Households chosen from each village

Econometric Tools and Variables

The information about predictor variables had been taken from household surveyors. The informatics variable included in this analysis were bifurcated into sub components-maternal care, education level, income level, childcare and consumption of diet taken by child. All these important variables were hanging in the category of socio economic determinants and maternal & child healthcare.

Under maternal care, the Maternal Health Index was composed through Principal Component Analysis, which had taken fifteen variables related to antenatal care, delivery care and post-natal care. After that, education level consisted of both father and mother's qualification level. Under income level, the wealth quintiles were computed through Principal Component Analysis likewise Maternal Health Index. Childcare had taken the sub variables such as fully vaccinated, Body Mass index level at the birth time, breastfeeding, health problems and its treatment. While consumption of diet included intake of three meals, body building food and protective food. All the above mentioned predictors were considered in the analysis in order to find the effects on child's health.

The main outcome variable's child's health was redesigned into Child Health Index because there was no single variable, which can define child health. All the variables were correlated work on each other. Fourteen utmost important variables were put in the basket of Child Health Index such as child checkup within 48 hours, exclusive breastfeed, vaccination and oral doses, health illness and intake of full balanced diet. Through Principal Component Analysis, Index was prepared to explore the influential results in regression analysis.

A Multinominal Logistic Model is a combination of Binomial Logit Models. However, it is bit different from Multiple Linear Regression in some way. An outcome variable in Multinominal Logistic Model is always categorical in nature and predictor variable can be continuous or/and categorical.

In medical research, this model is widely used to predict the probability of particular disease

(Andy Field, 2009). In other words, Multinominal Logistic Regression is used to model nominal outcome variables in which log odds of outcomes are modeled as a linear combination of the predictor variables. When the dependent variable is of nominal nature with more than two categories, it is obvious to use Multinominal Regression. Similarly, in this section Multinominal Logistic Regression has been run on child's health indicators to maternal health indicators. Before conducting the model, the indicators are combined into composite index (MHI and CHI) which have already been discussed in above section. In this model, the main aim is to find the effect of maternal healthcare and other socio economic determinants on child's health. For instance, if mother receives any type of antenatal care during pregnancy or postnatal care after delivery, it will benefit exponentially to her child in later stage of life.

To find out influential results from data, Multinominal Logistic Regression model was chosen owing to umpteen number of categorical variables. For this purpose, the outcome variable Child Health Index (CHI) was categorized into three classes – low CHI, moderate CHI and high CHI. Similarly, Maternal Health Index (MHI) and wealth quintiles were also classified into three parts- low MHI, moderate MHI & High MHI and Poor, Medium & Rich respectively.

Results and Discussion

Table 2: Model-Fitting Information

Model	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC	BIC	-2 log likelihood	Chi-Square	DF	Significance
Intercept only	1358.331	1367.191	1354.331			
Final	537.218	749.844	441.218	913.114	46	.000

Table 2 describes the model fitting estimates of multinominal logistic regression of Punjab. The likelihood ratio $-\chi^2$ (46) was found statistically significant, indicating that outcome variable was significantly dependent upon predictor variables. In model fitting criteria, AIC, BIC and – 2 log likelihood were smaller, when more variables were added to the final model, represents better fit.

Moreover, the log likelihood measured the unexplained variability in data and difference depicted changes in the new variance explained model and the difference was estimated 913.113 (1354.331-441.218). The change was significant and both Multi Nominal Regression models (1, 2) were better fit than the original model.

Table 3: Pseudo R Square

Cox and Snell	0.771
Nagelkerke	0.867
Mc Fadden	0.670

Table 3 represents the measure of R^2 -Cox and Snell, Nagelkerke adjusted values. In case of Punjab, the Cox & Snell and Nagelkerke's values were close (0.771, 0.867). It indicates 77% variations are explained by explanatory variables.

Table 4: Likelihood Ratio Test

	Effect	Model fitting criteria			Likelihood ratio test		
		AIC of Reduced Model	BIC of Reduced Model	-2 log likelihood	Chi-Square	Df	Significance
	Intercept	537.218	749.844	441.218[a]	0.000	0	
Maternal Care	Maternal health index (MHI)	544.138	739.046	456.138	14.921	4	.005
	Antenatal care	533.474	737.242	441.474	.257	2	.000
	Child bear	532.423	727.331	444.423	3.206	4	.524
	Age at first child	535.048	729.956	447.048	5.830	4	.212
	Post-natal care within 48 hours	731.984	935.751	639.984	198.766	2	.000
Education Level	Father's education	530.780	725.688	442.780	1.563	4	.815
	Mother's education	544.642	739.550	456.642	15.425	4	.004

Income Level	Wealth Quintiles	544.357	739.265	456.357	15.139	4	.004
Child Care	Full vaccination	550.322	754.090	458.322	17.105	2	.000
	Exclusive breastfeeding	539.528	743.295	447.528	6.310	2	.043
	BMI level at birth time	537.516	732.424	449.516	8.299	4	.081
	Health problems	823.049	1026.816	731.049	289.831	2	.000
	Treatment of illness	534.687	738.454	442.687	1.469	2	.480
Consumption of Diet	Intake of three meals per day	680.403	884.170	588.403	147.185	2	.000
	Intake of body Building food	648.661	852.428	556.661	115.443	2	.000
	Intake of Protective Food	572.801	776.568	480.801	39.583	2	.000

Note: Author's Calculations

Table 4 shows the results of the likelihood ratio test and further used to ascertain the significance of predicted variables on the model. To evaluate, the differences in child healthcare, a list of sixteen variables was considered under five major components, which have been discussed earlier. One point to be considered here is that not all of the predictor variables were significant. The variable from first component of maternal care, such as, Maternal Health Index (MHI), antenatal care and postnatal care had significant main effect on the Child Health Index (CHI). Similarly, mother's education level was found to be significant as compared to father's education. The most influencing factor which determined child's healthcare was income level of particular household and was found significant, χ^2 (4)=15.139, p< .005. In case of childcare component, full vaccination, exclusive breastfeeding, health problems had significant effect on outcome variable. Consumption of diet such as three meals per day, bodybuilding food, protective food were significant at 1% level (p< 0.000).

Table 5: Parameter Estimates for model 1

Child health index	**B**	**Significance**	**95% CI for Odds Ratio**		
MODEL 1			**Lower Bound**	**Exp(B)**	**Upper Bound**
Intercept	2.247	.003			
MHI=1	-.475	.002	.162	.622	2.381
MHI=2	1.198	.005	1.360	3.315	8.078
MHI=3	0[b]				
ANC=0	-.103	.000	.310	.902	2.626
ANC=1	0[b]				
Childbear=1	.289	.566	.498	1.336	3.586
Childbear=2	-.084	.873	.328	.919	2.575
Childbear=3	0[b]				
Age =1	.738	.231	.626	2.093	6.999
Age =2	-.073	.890	.334	.930	2.591
Age=3	0[b]				
PNC_48= 0	-3.229	.000	.016	.040	.100
PNC_48= 1	0[b]				
F_Edu=1	-.049	.943	.251	.952	3.608
F_Edu=2	-.320	.605	.216	.726	2.439
F_Edu=3	0[b]				
M_Edu=1	1.519	.002	1.302	4.569	16.032
M_Edu=2	.503	.000	.558	1.654	4.901
M_Edu=3	0[b]				
Wealth Quintiles=1	-1.657	.001	.074	.191	.493
Wealth Quintiles=2	-.985	.003	.164	.374	.852
Wealth Quintiles=3	0[b]				
Full vaccination=0	-3.481	.001	.004	.031	.223
Full vaccination=1	0[b]				
Breastfeeding =0	-.711	.153	.185	.491	1.304
Breastfeeding=1	0[b]				
Birth_BMI=1	.051	.898	.482	1.053	2.300

Birth_BMI=2	-.490	.193	.294	.613	1.280
Birth_BMI=3	0[b]				
HEALTH PROBLEMS=0	2.803	.000	6.636	16.495	40.999
Health Problems=1	0[b]				
Treatment_Illness=0	.068	.864	.492	1.070	2.326
Treatment_Illness=1	0[b]				
Intake_3 meals=0	2.848	.000	6.752	17.253	44.083
Intake_3 meals=1	0[b]				
BB_Food=0	-2.230	.000	.054	.108	.214
BB_Food=1	0[b]				
Pro_food=0	-1.469	.000	.122	.230	.435
Pro_food=1	0[b]				

a. The reference category is: 1.
b. This parameter is set to zero because it is redundant.

Table 6: Parameter Estimates for model 2

Child health index	**B**	**Significance**	**95% CI for Odds Ratio**		
MODEL 2			**Lower Bound**	**Exp(B)**	**Upper Bound**
Intercept	-3.765	.004			
MHI=1	-.864	.001	.039	.421	4.521
MHI=2	1.182	.005	.841	3.261	12.647
MHI=3	0[b]				
ANC=0	-.525	.001	.076	.591	4.608
ANC=1	0[b]				
Childbear=1	1.802	.135	.571	6.063	64.345
Childbear=2	1.310	.268	.364	3.704	37.674
Childbear=3	0[b]				
Age =1	1.582	.115	.680	4.867	34.832
Age =2	.614	.437	.393	1.847	8.680
Age=3	0[b]				
PNC_48= 0	-1.922	.000	.016	.040	.100
PNC_48= 1	0[b]				
F_Edu=1	.354	.753	.158	1.425	12.892
F_Edu=2	.305	.726	.246	1.357	7.472
F_Edu=3	0[b]				
M_Edu=1	2.244	.003	1.219	9.427	72.880
M_Edu=2	-.492	.000	.140	.612	2.663
M_Edu=3	0[b]				
Wealth Quintiles=1	2.989	.004	.007	.050	.380
Wealth Quintiles=2	1.250	.001	.067	.286	1.221
Wealth Quintiles=3	0[b]				
Full vaccination=0	-3.750	.005	.001	.024	.565
Full vaccination=1	0[b]				
Breastfeeding =0	-2.955	.014	.005	.052	.548
Breastfeeding=1	0[b]				
Birth_BMI=1	.703	.339	.478	2.020	8.539
Birth_BMI=2	-1.307	.043	.076	.271	.961
Birth_BMI=3	0[b]				
HEALTH PROBLEMS=0	11.300	.000	.7893	1.069	2.361
Health Problems=1	0[b]				
Treatment_Illness=0	.885	.260	.520	2.423	11.286
Treatment_Illness=1	0[b]				
Intake_3 meals=0	8.636	.000	2.369	5.361	10.587
Intake_3 meals=1	0[b]				
BB_Food=0	-6.067	.000	.01	.02	.09
BB_Food=1	0[b]				
Pro_food=0	-3.375	.000	.010	.034	.117
Pro_food=1	0[b]				

a. The reference category is: 1.
b. This parameter is set to zero because it is redundant.

Table 5 and 6 depict the results of parameter estimates of models of Punjab. The output of individual parameter estimates was bifurcated into two parts – Model1 and Model2. In these models, the reference category was first category- Low Child Health Index (CHI) value. Hence, two parts (moderate CHI and High CHI) were compared with this category in order to evaluate results. In model 1 (table 5.33), Maternal Health Index (MHI) significantly predicted the outcome variable and had shown main effect on the Child Health Index (CHI). MHI was divided into three categories- MHI1 = Low, MHI 2 = Moderate, MHI 3 = High. Both MHI1 and MHI2 significantly found in relation to outcome variable, b = -0.475 & 1.198, Wald χ^2 = 0.481 & 6.952, p = 0.005 respectively. The odd ratio describes that, as the level of Maternal Health Index (MHI) changes from low (1) to high (3) the changes in the odds of moderate Child Health Index (CHI) compared to Low Child Health Index CHI is 0.622. In other words, the odds of a mother lying in high range of MHI and his child in moderate level of CHI as compared to low level of CHI were 1.60 time more than the mother who lie in low range of Maternal Health Index (MHI1). Asides this, at MHI 2 level, the odds were increased i.e. 3.315, indicated as mother receives more care; the probability of better child health will be more. Another variable Antenatal Care (ANC) had shown its effect on child health, b =.-0.103, Wald χ^2 = 0.036, p < 0.001. Here ANC = 0 signs null antenatal care during pregnancy and ANC =1 depicts full antenatal care received by pregnant women. The negative sign of beta coefficient indicated that predictor

variable was less likely to happen for outcome variable. As per the odds, the child (lying in moderate CHI) of mother who receive full ANC (1) is 1.1 times better than the child whose mother receives null antenatal care. However, child born by pregnant women and age at the time of first child were not found significant at 5% level. Thus, it did not affect the Child Health Index. The last variable of maternal care is postnatal care within 48 hours. PNC_48 = 0 means expectant mom does not receive any post-natal care after delivery and PNC_48 = 1 means full post-natal care. The odds ratio described that as the woman's level of care changes from null to high, the change in the odds of moderate CHI to Low CHI was 0.040. The odds of mother with full post natal care in combination of moderate Child Health Index as compared to low Child Health Index were 25 times more than the mother who receives null postnatal care. In case of education component, father's education did not show main effects on the outcome variable, while mother's education significantly predicted the Child Health Index, whether it was low or moderate. Here M_Edu =1 means illiterate, M_Edu = 2 means literate up to higher secondary and M_Edu = 3 denotes graduation and above. The odds of highly qualified mother (M_Edu = 3) in relation to moderate Child Health Index was 0.218 times more than the illiterate woman. In case of qualified mother up to higher secondary level (M_Edu = 2), the odds were 1.654.

Another most influencing factor i.e income level of households highly affects the status of child and mother. Therefore, it is important to predict the outcome variable. Wealth quintiles were bifurcated into three parts – poor (1), medium (2) and rich (3). The odd ratio of expectant mother from poor category in combination of moderate child health index was 0.191. The effect of having medium income status is approximately twice from the effect of having poor income status on child health. It means income level of household highly determines the healthy life of future generation. In the component of childcare, full immunization, health problems, consumption of diet to have such as intake of three meals, protective food and body building food were significantly predicted the main effect on the child's health. A child who is not fully vaccinated at proper time may suffer from unhealthy life. The child who was found fully vaccinated and is in moderate Child Health Index as compared to low CHI was 32 times better than the child who did not receive immunization. Similarly, the odds of children who suffered from health problems and are in Moderate CHI as compared to Low CHI, were 0.060. Furthermore, when the child starts intake of three meals, the change in the odds of moderate CHI as compared to Low CHI was 17.253. Likewise, the child who consumed bodybuilding food and was in moderate CHI, was 9 times better than the child who did not

consume such nutritious food. In case of protective food, the child was found four times healthier than the child with non-consumption of protective food.

Table 6 describes the parameter estimates of model 2 (High Child Health Index). The variables of maternal care such as Maternal Health Index (MHI), antenatal care and postnatal care were predicted the outcome variables. Child born by woman and age at the time of first child did not show main effects on Child Health Index, likewise in model 1. In case of Maternal Health Index, the odd ratio outlined that as the pregnant women shift from MHI (1) to MHI (3) the change in the odds of high CHI (3) as compared to low CHI (1) was 0.421. Moreover, the odds of a mother lying in high range of MHI and her child being in high level of CHI as compared to low level of CHI are 0.301 times better than the child whose mother lie in moderate range of Maternal Health Index (MHI2). Thus, it indicated that there was no big difference between MHI 2 and MHI 3. Another variable Antenatal Care (ANC) also shows its effect on child's health, b =.-0.525, Wald χ^2 = 0.252, p < 0.001. Although, its effect was less likely to happen on outcome variable but it was still significant. The odds of mother who received full antenatal care (ANC 1) in combination of high CHI (3) was found 1.692. It means the child of the mother who received null antenatal care was 1.692 times worse in health status as compared to the child whose mother enjoyed full medical care. Post-natal care is also crucial variable in maternal care component and is predicted to have significant effect on outcome variable, b = -1.922, Wald χ^2 = 17.632, p < 0.000. The effect of postnatal care was found less likely on high Child Health Index, as beta coefficient was negative. The mother who is attended by medical team after delivery (PNC_48 =1) and has child enjoys healthy life (CHI 3) as compared to the child who suffer from worse health status (CHI 1), was 25 times better than the child whose mother received null post-partum care. In case of education component, father's education did not show main effects on the outcome variable. While mother's education significantly predicted the Child Health Index, whether it was low or high. The odds of high educated woman (M_Edu = 3) in relation to high Child Health Index was 0.106 times more than the illiterate woman. On the other hand, the odds ratio had shown that as the woman's education level increases (M_ Edu (2) to M_ Edu (3)), the changes in the odds of high CHI as compared to Low CHI was found 0.612. In short, child's health status increases with improvement in qualification of mother.

The next factor income level of households highly effects the status of child and mother. Therefore, it was found significantly predict the outcome variable, b= 2.989& 1.250, Wald χ^2 = 8.405 & 2.855, p < 0.000. The odd ratio of expectant mother from poor category in combination of high child health index was 0.050. The effect of having medium income status was found approximately twice from the effect of having poor income status on child health. Asides this, the healthy child from high-income class was twenty times better than the child from poor category. In the component of childcare, fully immunization, health problems, consumption of diet such as intake of three meals, protective food and body building food were significantly predicted and shown main effects on the child healthcare. The statistics for fully vaccination were b = -3.750, Wald χ^2 = 5.347, p =0.005. The child who received fully vaccine and in high Child Health Index as compared to low CHI was 41 times better than the child who did not receive immunization. Similarly, the odds of child who suffered from health problems and in high CHI as compared to Low CHI were 1.069. Furthermore, when the child shift from meagre diet to full diet the changes in the odds of high CHI as compared to Low CHI was 5.361. In short, the child who had taken proper three meals per day and had healthy status was found 0.18 times better than those who did not take proper nutritious meals in a day. Likewise, the child who is consumed body building food and in high CHI is 50 times better than the child who did not consume such nutritious food. In case of protective food, the child was found 29 times healthier than non-consumption of protective food.

Conclusion

The study was mainly designed to explicate the impact of maternal care of women, income level, education level and child care on child health. Results revealed significant impact of

predictor variables on outcome variable except few variables. First of all, Maternal Health Index was found significant and tell those women had received full maternal care during pregnancy (lie in High MHI), the chances of children lying in high Child Health Index was found more. Simply, it demonstrates the diffusion of care from women to fetus. Another the socio determinant, education level particularly mother's qualification level was shown the impact on child health. The child of higher educated mother was found healthy as compared to the child whom mother was illiterate. However, father's qualification level was not found significant in this analysis. Asides this, the income factor was main contributor toward healthy life of the child. Henceforth, the child from rich household was probably healthy as compared to child from poor status. Moreover, childcare like vaccination schedule, breastfeeding, health problems and intake of nutritious foods per day was found important for child health. Thus, there is need of care towards pregnant woman for future generation. While exploring data in field survey, many women respondents blamed on their male counterparts for not receiving antenatal care in hospitals and mostly preferred home delivery of infants. In another way, there were umpteen number of reasons reported by respondents that were hindered in the path of maternal care and childcare such as lack of transport means in villages, income level, superstitions and illogical beliefs in villages and illiteracy among male counterparts. Although, countable number of welfare programmes are designed for giving healthy life to mother and infant such as Janani Surakhsha Yojna and Shishu Suraksha Yojna, but these efforts are worthless in front of illiteracy and superstitions among household. Ultimately, burden of illness whether it is physical or mental are always carried by woman. The main implication for this study is to create awareness about maternal child health among males rather than females.

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