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Maternal Height and Fertility Outcomes: A Poisson Regression Analysis

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Abstract

The role of the social and cultural determinants on reproductive behaviour of females is very significant in the society. Irrespective of the impact of socio-demographic factors on fertility, human biologists are determined to describe the link between fertility differentials and maternal shape. The survival of children is closely linked with the maternal size, especially with the height of mothers. Child mortality influences the reproductive behaviour of females. Hence, an attempt has been made to establish maternal height as a fertility differential. At first, a descriptive study of some fertility parameters have been done for the females classified on the basis of their height. After obtaining the supportive results, Poisson regression analysis is used to access the risk of getting high number of children ever born among different height groups of females along with some socio-demographic factors. The main finding of the study is that the survival among children of shorter females is low which leads them to go for higher number of births. Females height ≤150.0 cm have 4 percent more risk of getting high number of children ever born compared to females height >150.0 cm. Fertility and anthropometrics are two distinct phenomenon which interdependent upon various biological, genetic, and geographical factors, but the study depicts a significant impact of maternal height on human fertility process. Hence, the maternal height may be used as a predictor variable for further fertility research.

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Introduction

Human fertility is very complex process which is determined by a number of socio-cultural, psychological, economic, demographic, and anthropometric factors. These factors affect the volume of fertility in a society. Since, the fertility is a macro term usually used for a population, but it is regulated at the micro level by the couples individually based on their desired number of children or family size. The choice for the desired number of children varies according to the environment in which couples live. According to the prevailing concept of fertility behaviour, the main driving forces for responsible to reduce the desired fertility is structural socio-demographic changes in societies. The role of the social and cultural determinants on reproductive behaviour of females is very significant in the society. Some of the studies suggest about the value that couples assign to their children is prejudiced by the norms and attitudes of their social environments (Easterlin et al., 1980; Pollak et al., 1993; Bongaarts, 2002; Hakim, 2003 and Nauck, 2007). Also, these socio-cultural indicators appear to change the character and force for number of children during the demographic transition. Demographers and social scientists had evaluated the impact of these determining factors of fertility such as place of residence, (Garenne and Joseph 2010; Gurmu and Mace, 2008) religion, (Chamie, 1977; Chaudhury, 1984) economic status, (Andorka, 1987; Cleland and Wilson, 1987; Bongaarts, 2008) and educational level (Bongaarts, 2002; Martin, 1995; Basu, 2002; Cleland, 2002). These socio-demographic factors exposed a different pattern of desire for children based on traditional beliefs and norms of environment in which the couples use to live.

Irrespective of the impact of socio-demographic factors on fertility, human biologists are determined to describe the link between fertility differentials and maternal shape and to assess the evolutionary implications of these associations. In the past, some studies have been conducted to assess the role of anthropometric measures on the human fertility. Usually, the anthropometric measures are considered as the measures of health and nutritional status of an individual, but for the western societies, a number of literatures available which points towards the association of anthropometrics with the human fertility.

The first attempt to observe the impact of physical structure on fertility was done by (Davenport, 1923; Frassetto 1934; Clark and Spuhler, 1959). In these studies, it was observed that the stockier couples had larger families than lean couples. The association of foetal survival with the maternal size has been discovered by (Bernard, 1952; Bressler, 1962). The factors associated with tall stature of female such as enriched nutritional and socioeconomic level, have resulted in more successful pregnancy outcomes. The mortality of offspring examined and found that the mortality is significantly higher among the children of shorter women (Martorell et al., 1981). This leads the shorter women to go for higher parity as a compensation of losing their children. Similar results have been obtained that survival of children is higher for tall females (Sear et al., 2004). Literature review indicates that the survival of children is closely linked with the maternal size, especially with the height of mothers (Vetta, 1975;

Mitton, 1975; Malik, 1992). Also, number of studies already has been done to positively interconnect infant and child mortality with fertility. Studies stated that the fertility and infant/child mortality is interdependent (Talwalkar, 1981; Raivio, 1990; Palloni and Rafalimanana, 1999; Hossain et al., 2007; Soest and Saha,

2018). Another important study has which states that TFR can be predicted by IMR but vice versa does not exist (Singh et al., 2017). It means TFR (fertility) is regulated by IMR (mortality). Child survival regulates the reproductive decision making of couples. Hence, maternal stature has made its own way to affect the fertility behaviour of females.

Apart from past studies, there have been quite interesting studies have been conducted on the association of maternal stature with survival of children in the recent times. A study analysed the demographic data of 54 countries and found that the relative risk of dying among children born to the females having height less than 145 cm is around 40 percent more than the children born to the females having height greater than or equal to 160 cm (Ozaltin et al., 2010). In the context of India, NFHS-III data to conclude that the children born to females having height less than 145 cm were at 71 percent more risk of dying compared to the children born to females having height at least 160 cm (Subramanian et al., 2009). Similar type of result has been obtained in Bangladesh Demographic and Health Survey data collected in 2004, 2007, 2011, and 2014. The key finding of the study is that the children of shorter females i.e. having height less than 145 cm had 73 percent more risk of infant mortality and 48 percent more risk of child mortality compared with the tall females (height ≥ 155 cm) (Khatun et al., 2018).

It is evident from the past studies that the fertility or more precisely the number of children born to a female is interdependent on the survival of her children and the survival of children is somehow connected with the height of the female. Therefore, a curious intuition has emerged about the association of fertility with the maternal stature. At first, an exploratory study has been done to establish maternal height as a fertility differential

in the context of Indian society. Females who were surveyed during NFHS-II, NFHS-III, and NFHS-IV are differently classified on the basis of their height. Then, the authors have attempted to link fertility with the height of female by using some descriptive and inferential statistics.

METHODS

The present study has been done by using a number of socio-demographic variables such as place of residence, religion, caste, wealth index, educational level, family structure, and age at first birth along with height of females to identify the impact of maternal height on the number of children ever born to a female. The socio-demographic and anthropometric information of married females has been obtained from the three phases of National Family Health Survey (NFHS) dataset conducted in 1998-99, 2005-06, and 2015-16. For the descriptive study, the females residing in the major states of India are taken as study population. The females are two classification criterion are applied to group females based on their height. The first classification criteria divide females into 4 groups that are:

1.1 Females having height ≤ 4'10"

1.2 Females having height > 4'10" and ≤ 5'00"

1.3 Females having height > 5'00" and ≤ 5'02"

1.4 Females having height > 5'02"

The second criterion is based on the average height of Indian women estimated around 150 cm by National Institute of Nutrition, which is:

2.1 Females having height ≤ 150 cm

2.2 Females having height > 150 c

The females of Uttar Pradesh from NFHS-IV (2015-16) are considered as a target population for the inferential study due to vastness and social variability within the state. While applying inferential statistics, the number of children ever born to a female is considered as a fertility indicator which ranges between 0 and 15 for the selected females of Uttar Pradesh. Hence, Poisson regression model is the best suited regression model for the study instead of other regression model e.g. logistic regression model which would lose some information of children ever born in the present case.

Poisson Regression Model: Poisson Regression is a regression model with assumes that the dependent variable follows Poisson distribution. This model is used for the random variable having a value of $0, 1, 2, \ldots, n$.

For a random variable Y (children ever born) which follows Poisson distribution with parameter λ, the probability of y events (number of children) in unit time is-

$$\Pr(Y = y) = \frac{\lambda^y \cdot e^{-\lambda}}{y!} \quad ; \qquad y = 0, 1, 2, 3, \ldots \qquad (1)$$

The model in Poisson regression for each observation $y_i \ (i = 1, \ldots, n)$ can be written as

$$E(y_i) = \lambda_i$$

where λ_i is the mean number of children born in time t_i .Hence,

$$\ln(\mathrm{E}(y_i)) = \ln(\lambda_i) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n \qquad (2)$$

Equation (2) is denoted as Poisson regression model for the number of children ever born with *n* independent socio-demographic and anthropometric variables.

RESULTS

The estimates of fertility indicators i.e. children ever born, survival ratio of children, and the proportion of females at higher birth order for Indian females is given in table 1 and table 2. Table 1 represents first classification of females based on height where it is found that the mean number of children ever born is reducing as the increment in maternal height observed for all of the three NFHSs. While, the survival ratio of children is relatively high among the tall females compared to short females. The females of shorter height proceed for higher birth order with a greater proportion compared to short females.

Table 1 Average estimates of fertility indicators for the Indian females (classification 1)

Fertility Indicators	NFHS-II (1998-99)				NFHS-III (2005-06)				NFHS-IV (2015-16)			
	Females having height				Females having height				Females having height			
	≤ 4'10"	4'10"-5'00"	5'00"-5'02"	> 5'02"	≤ 4'10"	4'10"-5'00"	5'00'-5'02"	> 5'02"	≤ 4'10"	4'10"-5'00"	5'00"-5'02"	> 5'02"
Children ever born	3.44	3.35	3.28	3.09	3.18	3.08	2.98	2.79	2.97	2.82	2.69	2.51
Survival ratio of children	0.880	0.898	0.911	0.924	0.899	0.921	0.932	0.943	0.927	0.945	0.954	0.962
Proportion of females with 3+ birth order	0.619	0.604	0.589	0.547	0.565	0.546	0.520	0.463	0.533	0.490	0.453	0.395

Similar results have been observed in table 2 also, where the females are classified into two height groups. Shorter females have higher number of children ever born with lower survival ratio among children. They also have a tendency to go for higher birth order.

Table 2 Average estimates of fertility indicators for the Indian females (classification 2)

Fertility Indicators	NFHS-II (1998-99)		NFHS-III (2005-06)		NFHS-IV (2015-16)	
	Females having height		Females having height		Females having height	
	≤ 150.0 cm	> 150.0 cm	≤ 150.0 cm	> 150.0 cm	≤ 150.0 cm	> 150.0 cm
Children ever born	3.42	3.24	3.15	2.95	2.91	2.67
Survival ratio of children	0.886	0.912	0.908	0.933	0.934	0.954
Proportion of females with 3+ birth order	0.615	0.581	0.560	0.509	0.517	0.446

Table 3 presents the distribution of number of children ever born to the observed number of females along with the expected number of females by using Poisson distribution. It is observed that the bottom of observed number have an agreement with expected number of females according to the children ever born.

For a better visual understanding, the distribution of children ever born over the observed and expected number of females is given in figure 1. It depicts that the distribution of children ever born to

the observed number of females and expected number of females is almost similar.

As the literature review indicates that few selected socio-economic and demographic characteristics of females may affect the number of children ever born to a female. Table 4 displays the percentage distribution of females on the selected socio-demographic indicators along with the summary of number of children ever born. Here, it can be easily seen that around 70 percent of females belong to rural areas with 2.91 mean number of children ever born. While the proportion of urban females is around 30 percent having 2.67 mean number of children ever born.

Table 3 Distribution of number of children ever born and Poisson distribution

Number of children ever born	Observed number of females	Expected number of females
0	3269	2337.38
1	6456	6638.15
2	10015	9426.17
3	8105	8923.45
4	5256	6335.65
5	3134	3598.65
6	1853	1703.36
7	1022	691.08
8	510	245.33
9	230	77.42
10	101	21.99
11	36	5.68
12	12	1.34
13	5	0.29
15	2	0.07
Total	**40006**	**40006.00**

Around 80 percent of females belong to the Hindu community with 2.70 mean numbers of children ever born, while Muslim females have 3.41 mean number of children ever born. More than half of the eligible females belong to other backward classes (with 2.87 mean CEB) while 22.4 percent of females belong to SC/ST (with 2.99 mean CEB). About half of the female population belongs to an economically poor background. The mean number of children ever born has increased with decline in wealth index. One of the interesting facts found is that the percentage of females with secondary education is more than primary education due to the high proportion of the population living in rural areas. Only 12.8 percent of females are highly educated.

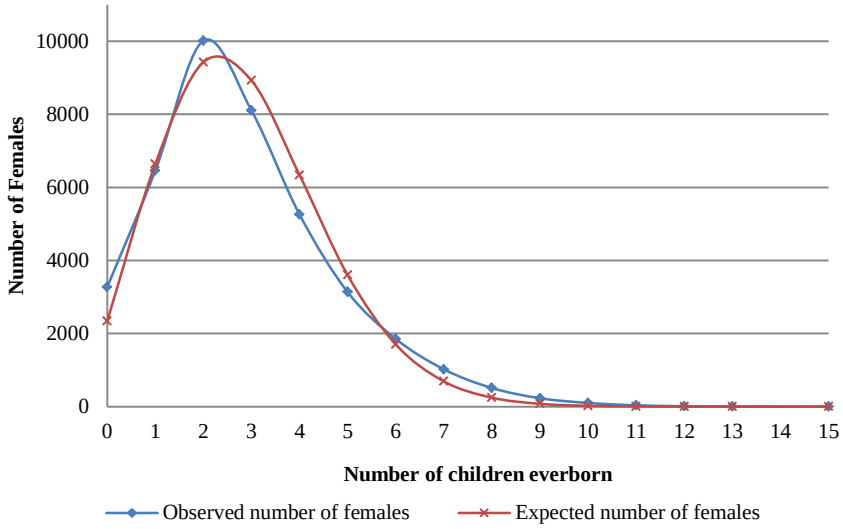

Figure 1 Observed and expected number of females according to the number of children ever born

The mean number of children ever born has decreased with the increase in the education level of females. Although the distribution of females based on their family structure is almost same, yet the mean number of children ever born to the females of nuclear family (2.54) is less than the joint family females (3.13).

Another observation reveals that 52.4 percent of females got married before reaching the legal marriage age i.e. 18 years with 3.19 mean number of children ever born. It is evident that 57.1 percent of female's height is found more than 150.0 cm and having 2.77 mean number of children ever born compared to 2.93 mean number of children ever born to the females having height less than or equal to 150 cm.

Table 5 shows the results of univariate Poisson regression model representing the impact of various socio-demographic variables on the number of children ever born (CEB). It is known that the place of residence plays a significant role in population decline which reflects from the table that the urban females are at 8 percent lower risk of having more CEB compared to rural females.

The religion-wise analysis shows that the Hindu females are 21 percent less likely to have high number of children in comparison of Muslim females. The family size is also influenced by the caste or ethnicity of household. Hence, it is observed that the females belonging to backward castes (OBC) have 4 percent lower risk of getting high CEB compared to the females belonging to SC/ST community. Among the females of other castes, the risk of having high CEB is around 13 percent less than SC/ST females. The impact of wealth index of household on the number of children ever born can be states as that both shares a negative association. The risk of getting high CEB is slightly reduced as the level of wealth index increases. Comparing with the females of poorest households, the poorer females have 8 percent less risk, the middle class females have 15 percent lower risk, the females of richer households have 20 percent lower risk, and the richest females are at 32 percent less risk of getting high number of

children ever born. Educational attainment has a great impact on the number of children ever born.

Table 4 Percentage distribution of females and summary of number of children ever born by some socio-demographic characteristics

Socio-demographic Characteristics		Percent	Number of Children ever born	
			Mean	Standard Deviation
Place of residence	Rural	69.8	2.91	1.93
	Urban	30.2	2.67	1.82
Religion	Hindu	80.1	2.70	1.77
	Muslim	19.9	3.41	2.29
Caste	SC/ST	22.4	2.99	1.96
	OBC	54.2	2.87	1.93
	Others	23.4	2.61	1.76
Wealth index	Poorest	22.3	3.31	2.13
	Poorer	21.4	3.06	2.00
	Middle	18.6	2.83	1.90
	Richer	17.5	2.67	1.78
	Richest	20.3	2.25	1.40
Educational level	Illiterate	40.7	3.67	2.14
	Primary	13.0	2.90	1.77
	Secondary	33.5	2.26	1.39
	Higher	12.8	1.64	0.97
Family structure	Nuclear	50.6	2.54	1.69
	Joint	49.4	3.13	2.05
Age at first marriage	≤ 18 years	52.4	3.19	1.98
	> 18 years	47.6	2.45	1.73
Maternal height	≤ 150.0 cm	42.9	2.93	1.98
	> 150.0 cm	57.1	2.77	1.85
Total		**100.0**	**2.84**	**1.90**

Though it is clear from the table 3 that higher educated females have 55 percent lower risk of getting high number of CEB in comparison of illiterate females. Similarly, primarily educated and secondarily educated females are at 21 percent and 39 percent less risk of getting high CEB compared to uneducated females. The females who lives in nuclear family, are 19 percent less likely to get high number of children in comparison of the females who live in joint family. Marriage is considered as the initiation of reproductive span of a female.

Table 5 Poisson regression analysis for impact of socio-demographic variables on number of children ever born

Socio-demographic Characteristics	Incident Rate Ratio	p-value	95 Percent Confidence Interval	
			Lower	Upper
Place of residence[1]				
Urban	0.916	0.000	0.905	0.928
Religion[2]				
Hindu	0.792	0.000	0.781	0.803
Caste[3]				
OBC	0.961	0.000	0.948	0.976
Others	0.874	0.000	0.859	0.889
Wealth index[4]				
Poorer	0.925	0.000	0.910	0.941
Middle	0.856	0.000	0.841	0.871
Richer	0.806	0.000	0.792	0.821
Richest	0.679	0.000	0.667	0.692
Educational level[5]				
Primary	0.788	0.000	0.774	0.802
Secondary	0.614	0.000	0.606	0.623
Higher	0.448	0.000	0.438	0.458
Family structure[6]				
Nuclear	0.813	0.000	0.803	0.822
Age at first marriage[7]				
>18 years	0.767	0.000	0.758	0.777
Maternal height[8]				
>150.0 cm	0.946	0.000	0.935	0.957

Reference category- 1: Rural, 2: Muslim, 3: SC/ST, 4: Poorest, 5: Illiterate, 6: Joint, 7: ≤18 years, 8: ≤ 150.0 cm

Hence, age at first marriage holds a significant impact on number of children ever born. The females who have married after the age of 18 years have 23 lower risk of getting high number of children compared to the females who married before the age of 18 years. By considering anthropometric measure i.e. height of female in the study, it is observed that the females having height more than 150 cm are at 5 percent lower risk of getting high number of CEB in comparison of the females having height less than 150 cm. The table 6 represents the Poisson regression analysis on number of children ever born after adjusting some socio demographic variables. The regression model is adjusted for education and wealth index of female. Literature suggests that the both characteristics (education and wealth index) of female has a higher impact on her family size.

Also, the other factors like place of residence, caste, family structure, age at first marriage are influenced by the educational level and wealth index. Since, the objective of the study is to access the impact of anthropometric measures on fertility and the inclusion of both factors (education and wealth index) leads to lose the impact of anthropometric factors as well as other socio demographic characteristics of female which she holds by her birth. Hence, the model is being adjusted for education level and wealth index of the females.

Here, two models have been estimated to study the combined impact of selected factors on the number of children ever born. It is observed that place of residence, religion, caste, family structure, and age at first marriage show almost the same impact on number of children ever born in both the models. For example, the females whose age at marriage is greater than 18 years are 22 percent less likely to get high CEB than females whose age at marriage is less than or equal to 18 years. The

proposed predictor (maternal height) also indicates the significant risk level among females on number of children ever born. Females having height more than 150 cm have 4 percent lower risk of getting high number of CEB in comparison of the females having height less than or equal to 150 cm. In the adjusted model, all the predictor variables contribute to maximize the log-likelihood of the model. It is observed that -2LL is reduced after considering the height of the female as a predictor. It indicates that second model provides a better explanation of the number of children ever born and the proposed predictor in the second model i.e. maternal height show a significant impact on the number of children ever born to females.

Table 6 Poisson regression analysis adjusted for some socio-demographic variables on number of children ever born

Socio-demographic Characteristics	Incident Rate Ratio	p-value	95 percent Confidence Interval		Incident Rate Ratio	p-value	95 percent Confidence Interval	
			Lower	Upper			Lower	Upper
Place of residence[1]								
Urban	0.905	0.000	0.893	0.917	0.906	0.000	0.894	0.918
Religion[2]								
Hindu	0.756	0.000	0.745	0.767	0.755	0.000	0.744	0.766
Caste[3]								
OBC	0.926	0.000	0.913	0.940	0.928	0.000	0.915	0.942
Others	0.870	0.000	0.855	0.886	0.875	0.000	0.859	0.891
Family structure[4]								
Nuclear	0.838	0.000	0.828	0.848	0.838	0.000	0.828	0.848
Age at first marriage[5]								
>18 years	0.783	0.000	0.773	0.792	0.783	0.000	0.774	0.793
Maternal height[6]								
>150.0 cm	-	-	-	-	0.963	0.000	0.952	0.974
-2 Log Likelihood	155589.920				155550.164			

Reference category- 1: Rural, 2: Muslim, 3: SC/ST, 4: Joint, 5: ≤18 years, 6: ≤ 150.0 cm

CONCLUSIONS

The previous studies which were conducted in the context of western society suggest about the significant impact of maternal stature on the survival of children and fertility of mothers. Shorter females have more number of offspring but their children have lower survival ratio. The similar results have been obtained for the Indian women also. Hence, it can be stated that the fertility of females is associated with their height. Since, it is known that the maternal height plays a significant role in the survival of children and the fertility of females is influenced by the survival of their children. Therefore, on the basis of descriptive study, it can be concluded that the proposed predictor i.e. maternal height works a differential of human fertility also. However, fertility and anthropometrics are two distinct phenomenon which interdependent upon various biological, genetic, and geographical factors, but the study depicts a significant impact of maternal height on human fertility process. Hence, the maternal height may be used as a predictor variable for further fertility research. Fertility of India is approaching to the replacement level in coming years that indicates that the previously discovered socio-demographic factors of fertility have already started to achieve feasible state. Hence, a shift towards the anthropometric approach will improve the fertility studies.

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