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Analyzing Number of Children Ever Born in Bangladesh Using Generalized Poisson Regression Model

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Abstract

One major indicator to detect any country's future population size is the total fertility rate (TFR). Based on the total number of children ever born, an underdispersed count data, this paper aims to investigate the fertility behavior of mothers in Bangladesh who have given birth to one or more children. For analyzing count dataset, the Poisson regression model (PRM) is commonly used, which assumes that the response variable's mean is equal to its variance. Since the generalized Poisson regression model (GPRM) is suitable for the analysis of both overdispersed and underdispersed count data, this model is applied to deal with the underlying count dataset in this study. The results obtained in this paper have revealed some variables that impose significant impact on the current fertility differential of mothers giving birth to children.

Keywords: Total fertility rate; number of children ever born; underdispersion; generalized Poisson regression

I. Introduction

The fertility rate is one of the major significant contributors to determining any country's population size and structure[1]. Rapid population growth negatively impacts the overall socioeconomic development and contributes to child malnutrition. The number of ever born children is a vital demographic indicator used to analyze fertility rates and patterns within a population, providing insights into the reproductive history and behavior of a particular group of individuals. It refers to the sum or aggregate count of all the alive born children to a particular group of individuals, typically women, within a given population or demographic group[2]. This statistic includes all live births, regardless of the children's current status, such as whether they are alive or deceased.

Fertility behavior has been modeled and studied in different manners in the literature. Barmby and Cigno used a sequential probability model to estimate fertility patterns[3]. A non-linear simultaneous probit model was used by Sobel and Arminger to study fertility decisions[4]. In recent years, different count models have also been used for modeling the variables associated with the fertility pattern and growth rate. The Poisson distribution establishes the core of all other count distributions[5,6]. It is the most familiar distribution in the case of modeling count data but with an assumption of variance equal to the mean[7]. However, in practice, count data often exhibit underdispersion or overdispersion, and as a result, the PRM is hardly used in practice[8]. Ignoring overdispersion or underdispersion in analysis may lead us to invalid results. The generalized Poisson regression model (GPRM) can deal with both the underdispersed and overdispersed count data[9]. Ratna et al. previously used the GPRM for modeling the number of children ever born in Bangladesh[10]. Kiser and Hossain also estimated the number of ever born children through the application of zero truncated count model[11]. Several potential factors detecting the number of ever born children in Bangladesh were also revealed in a work of Uddin et al.[12].

Bangladesh is the most densely populated country in the world. Sustained high population growth rates are viewed as the primary impediment to the country's sustainable development. If the prevailing population growth rate of Bangladesh persists, we will soon witness a doubling of its population. Therefore, efforts should be made to reduce the population growth rate as much as possible in order to expedite the nation's overall development.

In this paper, to identify the potential factors that are significantly affecting the number of ever born children of Bangladesh**,** the GPRM has been applied. A brief description of the used dataset and statistical methods has been presented in the next section, which is followed by results and discussion. Some useful recommendations made by the study are given in the conclusion section.

II. Data and Methods

This paper uses Bangladesh Demographic and Health Survey (BDHS) 2017-18 data for the analysis purpose. The number of children ever born to a mother in Bangladesh is the count response variable in this study. In total, 4856 respondents have been considered throughout this paper. Information on some variables was recategorized using the survey data. The variable heard about family planning has been considered by grouping mothers who heard about

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family related planning on the radio, television, or in newspapers/magazines in the last few months. The variable named migration has been categorized by considering all the respondents living less than two years in their corresponding residences[13]. Toilet facility has been recategorized into two categories: safe and unsafe[15]. Use of contraceptives has been taken as a binary indicator of respondents currently using any contraceptives or not[9]. Number of ever born children is measured on the ratio scale, i.e., a quantitative variable. On the other hand, all the explanatory variables are categorical having at least two categories (independent groups).

A count generalized Poisson response variable Y_i (i = 1, 2,…) has the following probability mass function (pmf)[15]:

$$f(y_i, \mu_i, \alpha) = \left(\frac{\mu_i}{1+\alpha\mu_i}\right)^{y_i} \frac{(1+\alpha y_i)}{y_i!} \exp\left[\frac{-\mu_i(1+\alpha y_i)}{1+\alpha\mu_i}\right]$$

$y_i = 0,1,2,\cdots$ and $\mu_i = \mu_i(x_i) = \exp(x_i'\beta)$, where $x_i = (x_{i1}, \cdots \cdot, x_{ij}, \cdots, \cdot, x_{ip})'$ be a $(p \times 1)$ vector of covariates, and $\beta = (\beta_1, \cdots, \beta_j, \cdots, \beta_p)'$ be a $(p \times 1)$ vector of regression parameters.

The expression of the mean and variance of the response variable Y_i are as follows:

$$E(Y_i) = \mu_i \text{ and } \mathrm{Var}(Y_i) = \mu_i(1+\alpha\mu_i)^2.$$

The GPRM works differently in different situations:

- when $\alpha = 0$, it reduces to Poisson
- when $\alpha > 0$, it represents overdispersion
- when $\alpha < 0$, it represents underdispersion

Here, the dispersion parameter is denoted by α. The generalized linear model (GLM) can be used for various data types and have many beneficial computational properties[16]. In GLM, we are primarily interested in modeling the response variable's mean in the presence of a given combination of covariates and corresponding regression parameters. The GLM for a response that follows generalized Poisson distribution can be written as $ln\mu_i = x_i^{'}\beta$. We can obtain the estimates of α and β by maximizing the log of the likelihood function as given:

$$l(\alpha, \beta; y) = \sum_{i=1}^{n} \left[y_i \ln\left(\frac{\mu_i}{1+\alpha\mu_i}\right) + (y_i - 1)\ln(1+\alpha y_i) - \ln(y_i!) - \left(\frac{\mu_i(1+\alpha y_i)}{1+\alpha\mu_i}\right)\right].$$

Data analysis has been conducted using the R function ‘vglm’ under the package ‘VGAM’.

III. Results and Discussion

Table 1 represents ANOVA F-test results as a means of bivariate analysis. Except for the mother’s age at last birth, BMI, and toilet facility, all the explanatory variables have been found to be associated significantly with the number of children ever born in Bangladesh at a 5% level of significance. From Table 2, we can see that the variance of the number of children ever born (1.57) is smaller than its corresponding mean (2.12), which reveals the presence of underdispersion. Table 3 represents the results that we obtained from the GPRM.

Table 3 shows that the average number of children ever born in the Chattogram and Sylhet divisions are significantly 25.5% and 55.1% higher than that of the Barishal division respectively. So, there is regional variation on the perspective of fertility behavior of mothers. The variable region was also found to affect fertility levels significantly in Nigeria, a study conducted previously[17]. Based on the results, place of residence also has a statistically significant effect on the total number of children born ($p < 0.001$, IRR=1.137). The rural mothers have higher fertility rate than that of urban mothers. The rural and urban inhabitants may have different reproductive decision making. Also, financial aspect and opportunity costs of childbearing may lead to decline in the level of fertility of the urban mothers[17]. Religion of the respondent has also been found to significantly associated with the total number of children born ($p < 0.001$, IRR=1.175). A similar finding was reported in a study already conducted in Bangladesh[12]. The effect of the mother’s BMI of on the fertility levels is also significant. Women with a BMI between 18.5 and 25 have, on average, 8.9% more children, while those with a BMI of 25 or higher have 9.1% more children compared to women with a BMI less than 18.5.

Table 1. Average number of children ever born by the selected variables along with p-values of ANOVA F-test

Variable	Average number of children ever born (95% CI) living children (95% CI)	p-value
Region		<0.001
Barishal	2.07 (1.97, 2.17)	
Chattogram	2.27 (2.18, 2.36)	
Dhaka	2.01 (1.92, 2.09)	
Khulna	1.91 (1.82, 2.00)	
Mymensingh	2.13 (2.02, 2.23)	
Rajshahi	1.93 (1.84, 2.02)	
Rangpur	2.04 (1.95, 2.13)	
Sylhet	2.48 (2.36, 2.61)	
Place of Residence		<0.001
Urban	2.04 (1.98, 2.09)	
Rural	2.17 (2.12, 2.21)	
Religion		0.001
Islam	2.15 (2.11, 2.18)	
Others	1.86 (1.76, 1.96)	
Mother's Educational Level		<0.001
No education	2.25 (2.10, 2.40)	
Primary	2.15 (2.08, 2.22)	
Secondary	2.11 (2.06, 2.16)	
Higher	2.06 (1.98, 2.14)	
Age of Mother at Last Birth		0.111
<20	2.08 (2.02, 2.14)	
20 – 35	2.14 (2.10, 2.19)	
>35	2.05 (1.86, 2.23)	
BMI		0.216
<18.5	2.03 (1.96, 2.11)	
18.5 – 25.0	2.16 (2.11, 2.20)	
25 +	2.10 (2.02, 2.17)	
Heard about Family Planning		0.039
Yes	1.91 (1.84, 1.98)	
No	2.17 (2.13, 2.20)	
Use of Contraceptives		<0.001 0.039
Yes	2.14 (2.09, 2.18)	
No	2.09 (2.03, 2.16)	
Toilet Facility		0.236
Safe	2.08 (2.04, 2.13)	
Unsafe	2.18 (2.12, 2.24)	
Migration		0.009
Yes	2.13 (2.09, 2.17)	
No	2.07 (1.99, 2.16)	

Table 2. Descriptive statistics for the response variable

Sample Characteristics	Number of children ever born
Size	4856
Mean	2.12
Variance	1.57

Table 3. Results of the selected covariates on the total number of children ever born in Bangladesh

Variable	Coefficient	SE	p-value	IRR
Constant	0.543	0.022	<0.001	1.721
Region				
Barishal	-	-	-	-
Chattogram	0.227	0.039	<0.001	1.255
Dhaka	0.117	0.065	0.071	1.124
Khulna	0.044	0.073	0.550	1.045
Mymensingh	0.099	0.074	0.182	1.104
Rajshahi	0.036	0.076	0.631	1.037
Rangpur	0.028	0.075	0.710	1.028
Sylhet	0.439	0.067	<0.001	1.551
Place of Residence				
Urban	-	-	-	-
Rural	0.128	0.064	<0.001	1.137
Religion				
Others	-	-	-	-
Islam	0.161	0.033	<0.001	1.175
Mother's Educational Level				
No education	-	-	-	-
Primary	-0.038	0.044	0.374	0.963
Secondary	-0.042	0.045	0.268	0.959
Higher	-0.052	0.049	0.132	0.949
Age of Mother at Last Birth				
<20	-	-	-	-
20-35	0.016	0.023	0.507	1.016
>35	-0.035	0.058	0.569	0.966
BMI				
<18.5	-	-	-	-
18.5-25.0	0.084	0.025	<0.001	1.089
25.0+	0.087	0.029	<0.001	1.091
Heard about Family Planning				
No	-	-	-	-
Yes	-0.128	0.024	<0.001	0.880
Use of Contraceptives				
No	-	-	-	-
Yes	0.052	0.018	0.005	1.053
Toilet Facility				
Unsafe	-	-	-	-
Safe	-0.065	0.032	0.043	0.937
Migration				
No	-	-	-	-
Yes	0.115	0.070	0.099	1.122

Several adverse impacts on reproductive ability and, hence, reduced fertility can result from low BMI[18]. The hearing about family planning ($p < 0.001$) positively impacts the number of child bearing. Women hearing about family planning have 12% lower mean number of children bornthan those who have not heard about it. Our study finds an interesting positive association of contraceptive use with increasing fertility rate. It may happen that women who have already achieved their desired number of children may choose to use contraceptives to prevent further pregnancies[19,20]. Table 3 also suggests that the variable toilet facility plays a statistically significant role in determining the mean number of children ($p < 0.043$, IRR=0.937). Respondents with safe toilet facilities have a 6.3% lower mean number of children born than those having unsafe toilet facilities. Use of safe toilet facility, indicating economic development, improves living standard which in terms limits fertility[21].

IV. Conclusion

The effects of a number of selected determinants on the total number of ever born children, which plays immense roles in explaining the fertility rate of Bangladesh, through the use of GPRM in the BDHS, 2017-18 dataset have been presented in this paper. It is evident from the results that fertility rate among mothers varies significantly across regions, urban and rural areas, and religious affiliations. Factors such as BMI and use of contraceptives have significantly positive influence on increasing the total number of children ever born in Bangladesh. Whereas, hearing about family planning and using safe toilet facility are associated with decreased number of children ever born. For a better understanding of the different levels and patterns of fertility, some recommendations might be suggested based on the study findings. Emphasis should be given in order to raise consciousness among the rural women, as well as women living in Chattogram and Sylhet divisions. Meanwhile, the use of contraceptives and safer toilet facilities need to be given priority. Furthermore, consciousness must be enhanced regarding the hearing about family planning through radio, television, or newspapers/magazines.

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