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Analyzing Overdispersed Skilled Antenatal Care Visits of Pregnant Women in Bangladesh Using Generalized Poisson Regression Model

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Abstract

It is common to use the Poisson regression model (PRM) for analyzing the count data. The major limitation of this PRM is that the mean and variance of the response variable need to be equal. However, in the actual dataset, the response variable's variance may exceed the mean, introducing overdispersion in the dataset. In this paper, the generalized Poisson regression model (GPRM) has been used in the modeling and analysis of the skilled antenatal care (ANC) count data extracted from the Bangladesh Demographic and Health Survey (BDHS) 2017-18. The findings of this study have revealed several socioeconomic and demographic variables that significantly impact the skilled ANC visits.

Keywords: Skilled ANC visits; Overdispersion; Generalized Poisson regression

I. Introduction

Nowadays, there is an overwhelming interest in modeling count data in various disciplines. ThePoisson distribution provides the basis of all count distributions [1, 2]. So, the Poisson regressionmodel (PRM) is regarded as the benchmark model for modeling count data in the presence of a setof covariates. One essential assumption of the PRM is that the mean is equal to the variance.However, such an assumption is too restrictive because empirical count data almost always exhibitoverdispersion or underdispersion and/or an excessive number of zeros, and as a result, the PRM isof limited use[3]. Overdispersed nature of count data is widespread in almost all practical situations[4]. Ignorance of overdispersion in count data analysis gives invalid interpretations of results. Several models have been proposed for modeling such data. One of the models used to overcome overdispersion in count data analysis is the Generalized Poisson regression model (GPRM) [5].

One of the most vitally concentrated issues for developing countries is maternal health care during pregnancy. Complications occurring during pregnancy and childbirth are the most significant causes of death and disabilities among women in Bangladesh[6-8].Unfortunately, in developing countries like Bangladesh, minimal actions have been taken by the concerned authorities to reduce maternal mortality. Antenatal care (ANC) is one kind of medical supervision given to a woman who is pregnant. It includes various routine examinations and tests. Currently, ANC visits are being practiced worldwide, which originated almost a century ago from the models developed in Europe [9]. ANC prepares pregnant women for safe deliveries and educates them about the importance of pregnancy and childbirth-related complications. Ensuring the utilization of services related to ANC, more specifically, an adequate number of ANC visits, plays an immense role in lessening maternal and child deaths[10]. At least eight ANC visits under normal circumstances of pregnancy have been recommended by the World Health Organization (WHO) to ensure safe motherhood[11]. For such reasons, it becomes interesting to find out the factors that significantly dictate the number of ANC visits of pregnant women. Several studies conducted in Bangladesh have identified many socio-economic and demographic variables associated with ANC visits and delivery care[12-15]. The education and economic condition of the pregnant women residing in urban slums of Bangladesh were found to be strongly associated with the study conducted by Kabir and Khan [16]. Through logistic regression analysis, Shahjahan et al. examined the association between availing the ANC-related services and different socio-demographic variables of rural women in Bangladesh and reported that education level, access to mass media, and birth order had significant effects on taking ANC service[17,18]. Mother's age at first birth highly affects the frequency of ANC visits of women during pregnancy[19]. A study conducted among the Bangladeshi pregnant women, who started to visit healthcare centers for attaining antenatal care services, reported that the educated women living in urban areas who belong to comparatively rich families and have access to mass–media were more likely to attend an adequate number of ANC visits compared with their counterparts [20].

The objective of this study is to illustrate the use of the Generalized Poisson regression model (GPRM) within the context of GLMs, for overdispersed count data. More precisely, the prime objectives are:

(i) To study the count data in the presence of overdispersion

(ii) To conduct a bivariate analysis to determine the relationship of different covariates with the number of skilled ANC visits of women during pregnancy in Bangladesh

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(iii) To determine the potential determinants of the number of skilled ANC visits of pregnant women in Bangladesh, using the GPRM

(iv) To provide recommendations for policy makers for the betterment of maternal health care.

II. Data and Methods

For the analysis purpose, data have been extracted from the Bangladesh Demographic and Health Survey (BDHS) 2017-18. BDHS 2017-18 is the eighth in a series of national level population and health surveys conducted to provide up-to-date information on the demographic and health status related to women and children of Bangladesh[21]. The women in the selected households who gave birth in the three years preceding the survey have been considered. For the women who gave birth to more than one live birth in the three years preceding the survey, we have considered the last birth only.

In this paper, ANC services haven defined as skilled only for those pregnant mothers who have received ANC-related services from one or more of the professionals: (1) doctors, (2) nurse/midwife/paramedics, (3) family welfare visitors, (4) sub-assistant community medical officers, and (5) community skilled birth attendants. Women's number of skilled ANC visits during their pregnancy in Bangladesh has been considered as the count response variable. Several demographic and socio-economic variables have been used as explanatory variables based on previous studies. Information on some variables was not found directly from the survey data. The variable age gap in years has been created by splitting the positive difference between the father's and mother's ages into three different categories. Migration has been computed by considering those respondents who have lived less than two years in their respective places of residence[21]. The variable exposed to media has been defined by categorizing mothers who read newspapers or magazines, listen to the radio, or watch television at least once a week[22]. Any woman involved as a member of at least one NGO: Grameen Bank, Bangladesh Rural Advancement Committee (BRAC), Proshika, and Association of Social Advancement (ASA); has been categorized as an NGO member[23]. Finally, the variable social barrier while receiving healthcare if a pregnant woman faced one or more of the four difficulties: getting permission to go for healthcare, getting money required for treatments, distance to health facilities, and not being willing to go alone for medical-related help.

A discrete random variable Y_i is said to have a Generalized Poisson distribution if it has a probability mass function (pmf) given by[23]:

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

$y_i=0,1,2,\cdots$ and $\mu_i=\mu_i\left(x_i\right)=\exp\left(x_i'\beta\right)$, where

$x_i=\left(x_{i1},\cdots,x_{ij},\cdots,\cdot,x_{ip}\right)'$ be a $\left(p\times1\right)$ vector ofcovariates,

and $\beta=\left(\beta_1,\cdots,\beta_j,\cdots,\beta_p\right)'$ be a $\left(p\times1\right)$ vector of regression parameters. The mean and variance of Y_i are as given: $E\left(Y_i\right)=\mu_i$ and $\mathrm{Var}\left(Y_i\right)=\mu_i\left(1+\alpha\mu_i\right)$.[2]

The GPRM works in the following ways:

reduces to Poisson if $\alpha=0$

possesses the trait of overdispersion for all values of $\alpha>0$

possesses the trait of underdispersion for all values of $\alpha<0$.

Generalized linear model (GLM) enables a large range of modelling and inferential problems in an effective standard framework. Using the log-link function, the GLM for generalized Poisson response can be written as $ln\mu_i=x_i'\beta$. The estimates of α and β can be obtained through the maximization of the log-likelihood function l(α, β; y) given as:

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

III. Results

Based on the reported p-values of ANOVA test in Table 1, the covariates region, residence type, educational level of mother, educational level of father, birth order number, wealth index, NGO membership of mothers, BMI, exposure of media, mother's working status, wanted pregnancy at the time, social barrier while receiving healthcare, desire for more children, migration, and the number of living children have been found to be significantly associated with the number of skilled ANC visits during pregnancy of women in Bangladesh at 1% level of significance. The highest average number of skilled ANC visits is found in the Khulna division (4.53), while the lowest is in the Sylhet division (2.89). The average number of skilled ANC visits for women in urban areas (4.52) is more than that of women living in rural areas (3.17). Women with no education and higher education have the lowest (1.86) and highest (5.27) visits, respectively. The same result is seen in the case of the father's educational level. The highest average number of skilled ANC visits (4.16) is found for the first birth and lowest (2.21) for the 4+ birth order.

It has been observed that pregnant women belonging to rich families receive the highest average number of skilled ANC visits (4.75). It is observed that despite having one or more NGO memberships, the average number of skilled ANC visits for women (3.60) is lower than that of the women who do not have NGO memberships (4.43). The findings in Table 1 also revealed that pregnant women with BMI 25+ have the highest number of visits (4.59), and it is lowest (2.95) for the mothers with BMI <18.5.

The findings delineate that the women with media exposure have much more mean number of skilled ANC visits compared to that of the women not exposed to media. Also, the average number of skilled ANC visits for employed pregnant women (3.46) is lower than that for unemployed pregnant women (3.73). Also, the number of visits is higher for the mothers who were expecting to be pregnant (3.78) than those who did not want pregnancy (3.06). The mean number of skilled ANC visits for mothers with social barriers while receiving services is 3.28, and it is 4.32 for the mothers who did not face any difficulty. Table 1 illustrates that the number of visits for the mothers who desire more children (3.94) is higher than that of the mothers who do not desire more children. The average number of skilled ANC visits during pregnancy for women who migrated in the last two years (3.95) is higher than for those who did not migrate.

Table 2 suggests that the variance of the number of skilled ANC visits (9.22) is much larger than the mean number of skilled ANC visits (3.63), which indicates the presence of overdispersion in the underlying dataset. For this reason, the generalized Poisson regression model is used for the analysis purpose.

Results obtained from the GPRM are represented in Table 3. This table contains the estimated regression parameters, estimated dispersion parameter, corresponding standard errors, p-values and incidence rate ratio (IRR).

It is observed from Table 3 that the average number of skilled ANC visits of women during pregnancy from the Khulna and Rangpur divisions are significantly 19% and 23% higher than women who live in the Barisal division. The result also shows that the residence type of pregnant women has a highly statistically significant (p-value < 0.001) effect on the mean number of skilled ANC visits. Women in rural areas receive 14% less mean skilled ANC than those in urban areas. Similar findings related to the region and residence type have been reported in a previous study conducted in Bangladesh[4].The association between the increasing number of skilled ANC visits and the increasing educational level of the mother is evident. Women with primary education, secondary education, and higher education received 27%, 46%, and 50% higher average skilled ANC visits during their pregnancy compared to women without no education. The same result is found for the educational level of fathers. These findings regarding the educational levels of mothers and fathers have been obtained in another study related to antenatal care visits in Bangladesh[24]. It is also seen that the average number of skilled ANC visits of women during pregnancy from rich and middle-class families are significantly found to be 17% and 27% higher, respectively, than that of women who belong to poor families.Again, the mean number of visits of pregnant women aged 20-35 years and greater than 35 years have significantly 8% and 24% higher, respectively, than that of pregnant women aged less than 20 years. The result also shows that the BMI of pregnant women significantly affects the mean number of skilled ANC visits.Pregnant women with a BMI of 18.5-25 and 25+ have 9% and 21% higher average skilled ANC visits, respectively, compared to pregnant women with BMI <18.5.For the media exposed pregnant women, the average number of skilled ANC visits is 27% higher than that of media non-exposed pregnant women A similar result has been found about the impact of media exposure on ANC visits in a previous study[25]. The average skilled ANC visits of working pregnant women is reported tobe significantly 5% higher compared to the non-working pregnant women.

Table 1. Mean number of skilled ANC visits by the socio-economic and demographic variables with p-values and 95% confidence interval (CI)

Covariate		Mean number of skilled ANC visits (95% CI)	p-value
Region			<0.001
	Barisal	3.34 (3.08, 3.60)	
	Chittagong	3.24 (3.06, 3.42)	
	Dhaka	4.21 (3.97, 4.45)	
	Khulna	4.53 (4.26, 4.80)	
	Mymensingh	3.26 (3.01, 3.51)	
	Rajshahi	3.89 (3.62, 4.16)	
	Rangpur	3.94 (3.68, 4.20)	
	Sylhet	2.89 (2.69, 3.09)	
Residence type			<0.001
	Urban	4.52 (4.36, 4.68)	
	Rural	3.17 (3.07, 3.27)	
Educational level of mother			<0.001
	No education	1.86 (1.60, 2.12)	
	Primary	2.65 (2.50, 2.80)	

Secondary	3.80 (3.68, 3.92)	
Higher	5.27 (5.07, 5.47)	
Educational level of father		<0.001
No education	2.36 (2.16, 2.56)	
Primary	2.89 (2.75, 3.02)	
Secondary	3.92 (3.78, 4.06)	
Higher	5.32 (5.12, 5.52)	
Birth order number		<0.001
1	4.16 (4.02,4.30)	
2-3	3.57 (3.45, 3.69)	
4+	2.21 (2.00, 2.42)	
Wealth index		<0.001
Poor	2.55 (2.43, 2.67)	
Middle	3.65 (3.46, 3.84)	
Rich	4.75 (4.62, 4.88)	
NGO membership of mothers		<0.001
Member	3.60 (3.51, 3.69)	
Non-member	4.43 (3.88, 4.98)	
Mother's age at last birth		0.058
<20	3.53 (3.37, 3.68)	
20-35	3.69 (3.59, 3.79)	
>35	3.24 (2.80, 3.68)	
BMI		<0.001
<18.5	2.95 (2.74, 3.16)	
18.5-25	3.45 (3.34, 3.55)	
25+	4.59 (4.40, 4.77)	
Exposure of media		<0.001
Exposed	4.28 (4.17, 4.39)	
Non-exposed	2.46 (2.34, 2.58)	
Age gap (in years)		0.051
<1	4.85 (3.82, 5.88)	
1-5	3.54 (3.39, 3.69)	
6-9	3.65 (3.52, 3.78)	
10+	3.65 (3.48, 3.81)	
Mother's working status		0.003
Working	3.46 (3.32, 3.60)	
Not working	3.73 (3.62, 3.84)	
Wanted pregnancy		<0.001
Yes	3.78 (3.68, 3.88)	
No	3.06 (2.88, 3.23)	
Social barrier while receiving care		<0.001
Yes	3.28 (3.18, 3.38)	
No	4.30 (4.15, 4.45)	
Desire for more children		<0.001
Yes	3.94 (3.81, 4.06)	
No	3.37 (3.25, 3.48)	
Migration		0.001
Yes	3.95 (3.74, 4.15)	
No	3.56 (3.47, 3.65)	
Number of living children	0.211*	<0.001

*Pearson Correlation Coefficient

Table 2. Descriptive statistics for the number of skilled ANC visits

Characteristics	Number of skilled ANC visits
Sample size	4856
Sample mean	3.63
Sample variance	9.22

Wanted pregnancy has a highly statistically significant (p-value < 0.001) impact on the increasing number of skilled ANC visits. The mean number of skilled ANC visits for the women who wanted to be pregnant at the time

Table 3. Effect of the selectedcovariates on the skilled ANC visits along with p-values and IRRs, obtained from the GPRM

Covariate	Estimate	SE	p-value	IRR
Intercept	0.807	0.166	<0.001	2.24
Region				
Barisal (ref.)	-	-	-	-
Chittagong	-0.093	0.050	0.065	0.91
Dhaka	0.077	0.052	0.140	1.08
Khulna	0.175	0.054	0.001	1.19
Mymensingh	0.057	0.053	0.280	1.06
Rajshahi	0.077	0.054	0.150	1.08
Rangpur	0.204	0.053	<0.001	1.23
Sylhet	-0.037	0.053	0.493	0.96
Residence type				
Urban (ref.)	-	-	-	-
Rural	-0.151	0.026	<0.001	0.86
Educational level of mother				
No education (ref.)	-	-	-	-
Primary	0.237	0.060	<0.001	1.27
Secondary	0.378	0.060	<0.001	1.46
Higher	0.405	0.069	<0.001	1.50
Educational level of father				
No education (ref.)	-	-	-	-
Primary	0.031	0.040	0.438	1.03
Secondary	0.153	0.043	<0.001	1.17
Higher	0.246	0.051	<0.001	1.28
Birth order number				
1 (ref.)	-	-	-	-
2-3	0.013	0.041	0.757	1.01
4+	0.002	0.079	0.979	1.00
Wealth index				
Poor (ref.)	-	-	-	-
Middle	0.161	0.034	<0.001	1.17
Rich	0.240	0.034	<0.001	1.27
NGO membership of mothers				
Non-member (ref.)	-	-	-	-
Member	-0.080	0.067	0.230	0.92

Mother's age at last birth				
<20 (ref.)	-	-	-	-
20-35	0.078	0.032	0.015	1.08
>35	0.217	0.076	0.004	1.24
BMI				
<18.5 (ref.)	-	-	-	-
18.5-25	0.084	0.033	0.011	1.09
25+	0.194	0.040	<0.001	1.21
Exposure of Media				
Non-exposed (ref.)	-	-	-	-
Exposed	0.239	0.028	<0.001	1.27
Age gap (in years)				
<1 (ref.)	-	-	-	-
1-5	-0.145	0.122	0.233	0.87
6-9	-0.146	0.121	0.230	0.86
10+	-0.127	0.123	0.299	0.88
Mother's working status				
Not working (ref.)	-	-	-	-
Working	0.051	0.025	0.042	1.05
Wanted pregnancy				
No (ref.)	-	-	-	-
Yes	0.102	0.030	<0.001	1.11
Social barrier while receiving care				
No (ref.)	-	-	-	-
Yes	-0.068	0.025	0.005	0.93
Desire for more children				
No (ref.)	-	-	-	-
Yes	-0.007	0.031	0.812	0.99
Migration				
Non-migrated (ref.)	-	-	-	-
Migrated	0.101	0.091	0.264	1.11
Number of living children	-0.126	0.023	<0.001	0.88
Region and Migration				
Barisal : Non-migrated (ref.)	-	-	-	-
Chittagong : Migrated	-0.135	0.119	0.257	0.88
Dhaka : Migrated	-0.268	0.114	0.018	0.91
Khulna : Migrated	-0.057	0.127	0.656	1.24
Mymensingh : Migrated	-0.261	0.134	0.052	0.90
Rajshahi : Migrated	-0.098	0.135	0.466	1.08
Rangpur : Migrated	-0.184	0.126	0.145	1.13
Sylhet : Migrated	-0.177	0.122	0.147	0.89
-2 log-likelihood	220175			

ref. indicates reference group

is 11% higher than that of the women who did not want to be pregnant. The mean number of skilled ANC visits of pregnant women who faced a social barrier while receiving healthcare is 7% lower than those who did not face any social barrier. The number of living children is also revealed to have a highly significant impact (p-value < 0.001) on the number of skilled ANC visit The average number of skilled ANC visits decreases by 12% if the number of living children increases by one. The mean number of skilled ANC visits of

the migrated pregnant women living in Dhaka is 9% lower compared to the non-migrated pregnant women living in the Barisal division.

IV. Conclusion

In this study, necessary results are obtained by applying the GPRM using the latest survey data (BDHS, 2017-18). Among these significant factors, the educational level of mother, educational level of father, wealth index, mother's age at last birth, BMI, exposure of media, mother's working status, and wanted pregnancy at the time; have positive effects on the skilled ANC visits of pregnant women. On the other hand, significant factors, including the residence type, barriers while receiving healthcare, desire for more children, and the number of living children, negatively affect the skilled ANC visits of Bangladeshi women during their pregnancy. Based on the findings in this study, some recommendations might be suggested for increasing skilled ANC visits to lessen maternal and child mortality in Bangladesh. More attention should be given to raising awareness among women living in rural areas about receiving the required number of skilled ANC visits during pregnancy. Both male and female education is needed to be given priority for the enhancement of skilled ANC visits. Moreover, the importance of skilled ANC visits to pregnant women in the Sylhet division should be emphasized. Again, attention should be given to facilitating women's access to the media and dispelling the barriers faced during pregnancy to increase the number of skilled ANC visits in Bangladesh.

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