Research Journal of Mathematical and Statistical Sciences _____E-ISSN 2320-6047
Vol. **4(10),** 1-9, November **(2016)** *Res. J. Mathematical and Statistical Sci.*

Factors Affecting Children Ever Born (CEB) in Botswana: Application of Poisson Regression Model

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Available online at: www.isca.in, www.isca.me
Received 16th August 2016, revised 8th November 2016, accepted 11th November 2016

Abstract

The number of children ever born to a particular woman is a measure of her lifetime fertility experience up to the moment at which the data are collected. Fertility is one of the key determinants of population growth and pattern and is essential for planning and achieving sustainable development. This paper attempts to identify the socioeconomic and demographic determinants of number of children ever born (CEB) to women of age 15-49 years using 2007 Botswana Family Health Survey-IV (2007 BFHS IV) data. Poisson regression model is explored to study the impact of potential regressors on fertility. The results indicate that the women living in cities/towns and urban villages had 11.2% and 6.8% lower fertility than women living in rural area; as expected percentage of number of kids was consistently decreasing with decrease of age groups. Women in the age group 45-49 have the higher number of kids than any other lower age groups. Mother's education negatively affects the average number of children ever born to a woman; women with married status have the highest fertility, with 21.7% more kids than women with never married status. Non-working mothers have more number of children ever born than the working mothers and mothers who watch television at least once a week have lower by 9.9% kids who do not watch television at all. Women/her partner who were currently using condom had a lower fertility by 8.1% compared to those who have never used. On the above findings we recommend that more emphasis is needed on women's literacy which may take care of other social and economic indicators.

Keywords: Children ever born (CEB), Poisson regression, Negative binomial regression.

Introduction

Children ever born (CEB) to women in a particular age group is the mean number of children born alive to women in that age group. The number of children ever born to a particular woman is a measure of her lifetime fertility experience up to the moment at which the data are collected. Fertility is one of the key determinants of population pattern and is also important in resource planning and development.In most cases, the mean number of children ever born is computed as the ratio of the number of children born alive to all women in a particular age group to the total number of women.

The world's total fertility rate (TFR) in 2012 was2.4; it was 1.7 for developed countries, 2.7 for less developed countries and 5.05 for sub-Saharan Africa[1]. Previous studies on the levels and trends of fertility in sub-Saharan Africa indicated three countries (Botswana, Zimbabwe, and Kenya) as the pioneers of the fertility transition that is currently underway in the region[2-7]. Fertility began to decline in Botswana and Zimbabwe in the 1970s, while in Kenya the decline was first observed in the 1980s[8]. Botswana TFR (Total Fertility Rate) between 1971 and 1981, increased slightly from 6.5 to 6.6 births per woman and then falling from 6.6 to 3.3 births per woman in 2001 and 2.7 in 2011. It is evident that Botswana is a country of a relatively low and declining fertility[9].

The data on direction of Botswana's fertility and other demographic indices is limited, thus to track the fertility outcomes mathematical modeling is explored.This study aims at i. model using the Poisson regression model to individual woman's fertility level and identifies socioeconomic determinants which determine fertility among women, and ii. examining empirically the validity of the proposition that fertility is a function of socio-economic and demographic variables. The results of this study could be useful in policy formulation that will go towards strengthening the family planning program and implementation of population programs in Botswana.

Methodology

Study design and data collection: The study was retrospective cross-sectional in design and utilized 2007 Botswana Family Health Survey (2007 BFHS) conducted by Statistics Botswana (then Central Statistics Office). The survey design, data collection procedures etc. have been exclusively provided in 2007 BFHS report on Statistics Botswana website[10].

Description of the variables: Response variable: Y: Children Ever Born (CEB) to women of age 15-49 is used to study the hypotheses about general behaviour of fertility to each woman. For the present study, children ever born is defined as the

number of children born alive to a woman earlier than the time of the study.

Discrete predictors or factors or independent variables:

X_1	Mother's place of residence (Cities/towns, urban villages and rural)
X_2	Mother's age groups (5 years age group between 15-49 years)
X_3	Mother's education (Primary, secondary or higher, no-education)
X_4	Mother's marital status (Married, living together*, others, andnever married)
X_5	Mother's employment (Working, Not working)
X_6	Watch television once a week (Yes/No)
X_7	Mothers age at her first child birth (10-14, 15-24, 25-39 years)
X_8	Ever used condom by either partner (yes ever used, currently using, never used)

*A man and woman may live together like husband and wife (even if they don't stay together in the same locality) without having gone through any form of marriage ceremony.

Statistical Modeling and Data Analysis: When the mean of the count variable is relatively high, Ordinary Least Squares (OLS) regression techniques provide reasonable results. When the mean of the count is low, OLS regression yields inefficient, inconsistent and biased estimates[11]. Count data has vital importance in the area of demography. So count data models were preferred by many researchers[6,12-16]. Violation of equidispersion had compelled to prefer generalized Poisson regression model instead of standard Poisson regression model[6]. Individual household fertility decisions have been modeled in various ways in the literature. The fertility patterns were estimated using a sequential probability model, while non-linear simultaneous probit model was used by Baramby[17] and Sobel[18]. In recent years, the modeling of household fertility decisions has utilized Poisson type models[19,20]. In many empirical studies of fertility, the number of children in a household is modeled as a function of other social and economic variables, such as a female's education level and family income. This study estimates a reduced form equation for the number of children ever born, an approach generally in line with other economics based estimation procedure[21].

The total number of children ever born (CEB) per woman was used as a measure of fertility. In various demographic studies CEB is used as proxy for fertility[6,15,22]. Since CEB is a count outcome, Poisson regression model of generalized linear models (GLM) family has been used for the data analysis[23]. The generalized log-linear model for CEB under the assumption of Poisson error structure and link log has been used. Being Poisson regression model of nonlinear nature, has many advantages over the linear regression models. The Poisson regression model was recommended by previous researchers[24-26] and has been used in many studies[19,20]. Statistical Package for Social Science (SPSS) is a cohesive system for analyzing data. The analysis under this study is carried out using SPSS version 23.

Poisson regression model: The standard model for the count data is the Poisson regression model, which is a non-linear regression model. This regression model is derived from the Poisson distribution by allowing the intensity parameter μ to depend on covariates (regressors). If the dependency is parametrically and involves exogenous covariate but no other sources of stochastic variation, we obtained the standard Poisson regression. In Poisson regression it is assumed that the dependent variable Y, number of occurrences of an event (CEB), has a Poisson distribution given the independent variables $X_1, X_2, ..., X_8$,

$$\Pr\{Y = y\} = \frac{e^{-\mu}\mu^{y}}{y!} \quad ; \text{for } \mu > 0,\ y = 0,1,2...,. \tag{1}$$

where the log of the mean μ is assumed to be a linear function of the independent variables.

That is,

$$\ln(\mu) = \alpha + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_7 X_7 + \beta_8 X_8 = x'\beta; \tag{2}$$

$$where, \quad x' = [1 \quad X_1 \quad X_2 \quad ... \quad X_8] \tag{3}$$

α is intercept and *β's* are the Poisson regression coefficients.

This implies that μ is the exponential function of independent variables,

$$\mu = e^{\alpha+\beta_1 X_1+\beta_2 X_2+...+\beta_7 X_7+\beta_8 X_8} = e^{x'\beta} \tag{4}$$

For subject i

$$\ln(\mu_i) = \alpha + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_7 X_{7i} = x_i'\beta \tag{5}$$

This is often referred to as "Poisson loglinear model". We can also represent, regression coefficient exp{β_i} which represents a multiplicative effect of the i-th predictor on the mean. Increasing x_i by one unit multiplies the mean by a factor exp{β_i}.

The exp{β_i} is also known as Incidence Rate Ratio (IRR) which quantifies the direction and strength of relationship between predictors and dependent variable (CEB).

Goodness of Fit: A measure of discrepancy between observed and fitted values is the deviance. The deviance for Poisson responses takes the form $D = 2\Sigma\left\{ y_i \left(\frac{y_i}{\hat{\mu}_i} \right) + (y_i - \hat{\mu}_i) \right\}$.

For large sample an alternative measure of goodness of fit is Pearson's Chi-squared statistic with (n-p) degree of freedom, it

is defined as $\chi^2_p = 2\Sigma \frac{(y_i - \hat{\mu}_i)^2}{\hat{\mu}_i}$. The Akalike information criteria (AIC), a goodness of fit measure defined as (-2ln L+2k) where k is the number of parameters in the model and L is the likelihood function of the final model. Bayesian information criteria (BIC) a goodness of fit measure defined as $\frac{-2\ln L + k\ln(n)}{n}$ where n is the total number of observations.

Results and Discussion

Socio-economic and demographic characteristic of women and summary of their children ever born (CEB): Table-1 presents the percent distribution of women with summary of their children ever born (CEB). The distribution of women (respondents) who gave at least one child birth according to urban and rural was 62% and 38% respectively. The maximum (60%) women belong to age group 25-39 years. Most (93%) of the mothers were educated. Women who never married and living together were 40% and 35% respectively, while the married proportion was about 19% only. The proportions of working and not-working respondents were 43% and 57% respectively. About 62% respondents watch television once in a week. The proportion of women who gave first birth in the age group of 15-24 years was 88%. The use of condom by either partner was significantly high and as such around 88% of either partner were using condom.

The mean CEB (2.51) in rural area was higher than in urban settlements. The mean CEB by womens' age 15-19 years was 1.13 while it was 3.74 for those aged 45-49 years.As expected the mean CEB was more for mothers with no education (2.63), married marital status (2.52), and non-working (2.45) among their respective groups. Respondents who watch television once in a week had lower (2.24) CEB in comparison to who did not watch. Women or their partner currently using condom had the lowest (2.25) CEB to those who ever or never used condom.

Figure-1 shows the percent distribution of CEB into five categories and is apparent that about 33% of the respondents had no child, 22% had one child, 18%, and 11% respondents had two and three children respectively, while others (16%) had four and more children.

Generalized Linear Model (GLM) analysis: Model evaluation: The CEB (continuous variable) information provides a rudimentary check of the data for over dispersion. The ratio of the variance to the mean (2.36/2.25 = 1.05) indicate equidispersion for such large sample. SPSS GLM module doesn't compute multicollinearity statistics, thus SPSS linear regression module is used. The most widely-used diagnostic for multicollinearity is VIF (Variance Inflation Factor). The VIF value ranged between 1.2 and 1.5 which indicates no interrelationship among the predictors. The deviance (1787.8) was evaluated using Chi-square distribution with model degree of freedom (4185) and conclude that model fits reasonably well because the Chi-square test is not significant (p = 0.999) (Table-2).

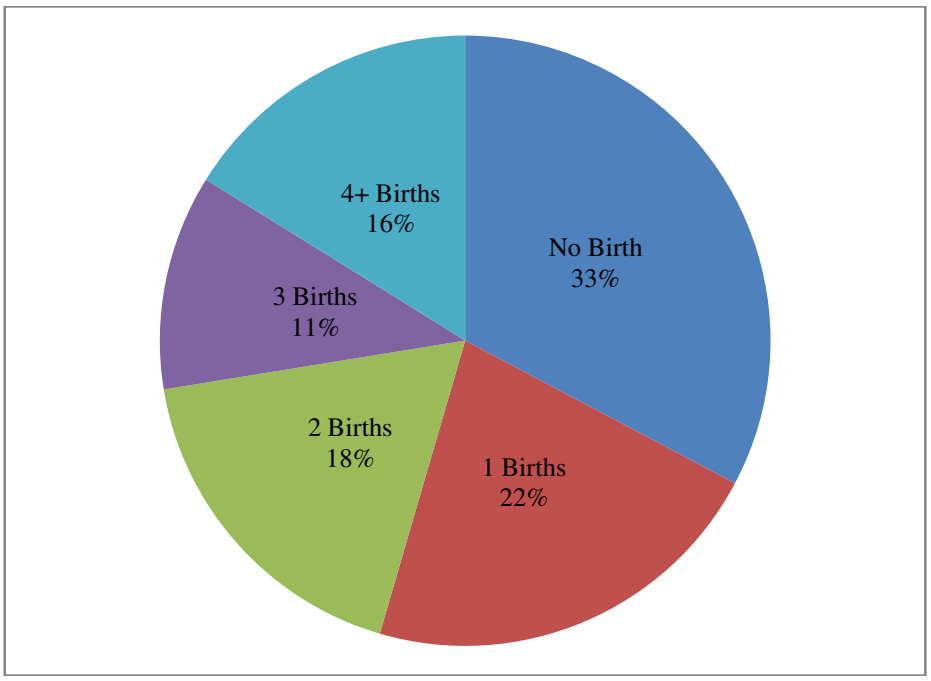

Figure-1
Distribution of CEB among Botswana women-2007 BFHS

Table-1
Children Ever Born (CEB) by socio-economic and demographic characteristics

Variable Characteristic		Standardized Weighted Percent of N= 4205	Mean CEB	Standard Error	95% Wald Confidence Interval	
					Lower	Upper
Place of Residence	Cities/Towns	26.4	2.23	0.0813	2.0776	2.3967
	Urban Villages	35.6	2.34	0.0819	2.1877	2.5091
	Rural	38.0	2.51	0.0818	2.3586	2.6795
Age Group	15-19	2.7	1.13	0.1065	.9376	1.3574
	20-24	16.3	1.49	0.0693	1.3584	1.6304
	25-29	21.9	2.14	0.0831	1.9874	2.3133
	30-34	20.3	2.68	0.0969	2.4984	2.8787
	35-39	17.5	3.19	0.1079	2.9867	3.4100
	40-45	12.0	3.53	0.1220	3.3033	3.7818
	45-49	9.4	3.74	0.1285	3.4996	4.0039
Mother's Education	Primary	25.0	2.48	0.0883	2.3079	2.6542
	Secondary and Higher	67.6	2.02	0.0651	1.8960	2.1513
	No Education	7.4	2.63	0.1086	2.4248	2.8510
Marital Status	Married	19.7	2.52	0.0910	2.3428	2.6999
	Living together	35.4	2.48	0.0815	2.3287	2.6485
	Others-Widowed, divorced	4.6	2.40	0.1184	2.1816	2.6465
	Never married	40.3	2.07	0.0681	1.9374	2.2044
Mother's Employment	Working	43.3	2.27	0.0787	2.1238	2.4326
	Not working	56.7	2.45	0.0775	2.3028	2.6070
Watch television at least once a week	Yes	62.5	2.24	0.0750	2.0976	2.3918
	No	37.5	2.49	0.0826	2.3297	2.6536
Mothers age at her first child birth	10-14	1.3	2.99	0.2134	2.6046	3.4437
	15-24	88.5	2.58	0.0545	2.4730	2.6867
	25-39	10.2	1.70	0.0707	1.5694	1.8468
Ever used condom	Yes, ever used	34.5	2.39	0.0816	2.2365	2.5566
	Currently using	52.9	2.25	0.0758	2.1039	2.4013
	Never used	12.5	2.45	0.0917	2.2720	2.6319
	Total	**100**	**2.53**	**0.0248**	**2.4814**	**2.5786**

Table-2
Goodness of Fit

	Value	df	Value/df
Deviance	1787.833	4185	0.427
Pearson Chi-Square	1794.237	4185	0.429
Log Likelihood[b]	-6517.961		
Akaike's Information Criterion (AIC)	13075.923		
Finite Sample Corrected AIC (AICC)	13076.123		
Bayesian Information Criterion (BIC)	13202.803		
Consistent AIC (CAIC)	13222.803		

b. The full log likelihood function is displayed and used in computing information criteria.

The **Omnibus Test**is a likelihood ratio test which compares the fitted model against the intercept-only model, since $p < 0.05$; it indicates that the model is statistically significant (Table-3).

Table-3
Omnibus Test [a]

Likelihood Ratio Chi-Square	df	Sig. (p value)
1914.846	19	0.000

a. Compares the fitted model against the intercept-only model Since $p < 0.05$, indicate that the model is statistically significant.

The test of model (Table-4) effects indicates that all 8 regressors are statistically significant predictors of CEB ($p<0.05$).

Table-4
Tests of Model Effects

Source	Type III		
	Wald Chi-Square	df	Sig (p value).
(Intercept)	749.177	1	0.000
Place of residence	20.997	2	.000
Mother's age-group	609.225	6	0.000
Mother's education	79.341	2	0.000
Mother's marital status	78.195	3	.000
Mother's employment	12.089	1	.001
Watch television at least once a week	21.341	1	.000
Mothers age at her first child birth	125.616	2	0.000
Ever used condom	11.564	2	.003

Figure-2 of predicted value of mean response verses standardised deviance residual specify that about 95% of the residuals are under absolute value of 2 indicating that model fit the data satisfactorily.

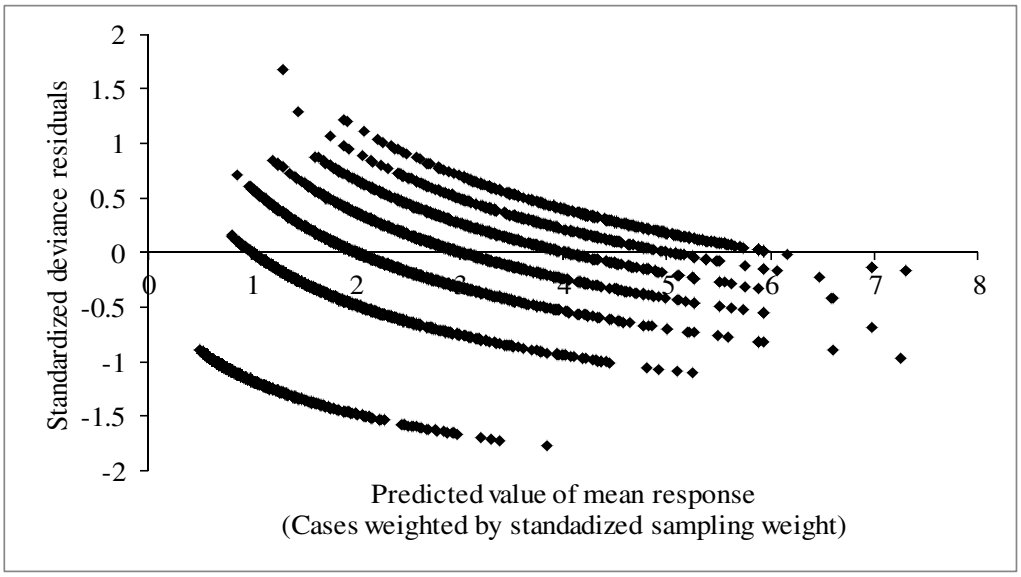

Figure-2
Predicted value of mean response (CEB) verses standardised deviance residual

Poisson regression results: The incidence rate ratio (IRR) which is the exponential of estimated Poisson regression coefficients along with its 95% confidence interval is depicted in Table-5.

The effects of residence show that women living in rural villages had the highest fertility. The women living in cities/towns and urban villages had 11.2% (IRR= 0.888) and 6.8% (IRR= 0.932) respectively lower fertility than women living in rural area. As expected the association of CEB with mother's age group shows that the women in the age group 45-49 had the highest number of kids than any other age groups. The percentage of number of kids was consistently decreasing with decrease of age groups. For example, women in the age group 25-29 have about 42.7% (IRR= 0.573) fewer kids than the women in 45-49 years. Compared to those women with no education, women who had primary secondary or higher education had fertility lower by 5.9% (IRR= 0.941) and 23.2% (IRR= 0.768) respectively. This indicates the inverse association of education and the number of children born per woman.

The effects of marital status show that married women had the highest fertility, that is, 21.7% (IRR= 1.217) more kids per women than women never married. The women living together and "other" marital statuses had respectively 20.2% and 16.3% more children than never married women. Mother's employment has negative impact on the number of kids. The results indicate that working mothers had 7.2% (IRR= 0.928), fewer kids compared to those not working. Although the coefficient could be undermined by high unemployment in the country, it supports the quality-quantity-trade off and may be considered as one of the factors influencing fertility in the nation. Access to media also turned out to be a crucial determinant of fertility. For those respondents who watched television at least once a week compared to those that did not watch television at all, their fertility was found to be lower by 9.9% (IRR= 0.901). The mother's age at her first child birth figures reveal that that the women whose age at first child birth was in the age groups 10-14 and 15-24 had 75.9% (IRR= 1.759) and 51.4% more kids respectively than 25-39 years old mothers. The percentage of number of kids is consistently increasing with decrease of age groups pertaining to her first child birth holding all other variables constant. To delay or avoid a pregnancy ever use of condoms by women or their partners figure indicate that the women who had ever used condom, compared to those who had never used, had a lower fertility by 2.2% (IRR= 0.978). Women (or partner) who were currently using condom had a lower fertility by 8.1% (IRR= 0.919) holding all other variables in the model constant.

Discussion: The study used the Poisson regression model to analyse the fertility (children ever born) of Botswana women of child bearing age (15-49 years) from the BFHS survey (BFHS, 2007) as reported on Statistics Botswana website[10]. Some basic socio-economic and demographic information of mother (respondent) were fitted into model. The findings indicate that place of residence, age, education, marital status, work status, access to media, age at first child birth and use of condom by either partner have significant effect on fertility level in Botswana. These findings are in accordance with earlier studies conducted in some part of Africa[1, 20, 27- 28].

Current analysis shows that urban fertility is less than rural indicating that fertility has started declining in urban areas. The reason for higher rural fertility is obviously due to differentials in education, use of contraceptives, and economic status of respondents and may be of opportunity cost of children among urban and rural. In rural areas there is also lack of accessibility to contraceptives and health facility. This finding is in agreement with the findings of Kibirige[29] and Onoja[30].

Age of women is one of the most important biological and demographic determinants of fertility. It is natural that an older woman has more number of children as compared to her younger counterpart. This study revealed the inverse association of CEB with mother's age group; it shows that the women in the age group 45-49 had the highest number of kids than any other age groups starting at 15 years. Many fertility related studies have concluded the positive relationship between age and fertility for various countries i.e. Korea, USA, Jordan, Oman, Yemen West Bank of Gaza, Greece, India[6,12,16,31].

Most of studies conducted in various countries with reference to fertility determinants produced significant inverse relationship between women's education and fertility. In the present study we also found that as level of education increased, the number of children born per woman reduced. Women who had secondary or higher education had less number of children than the women without education or those with primary education. These findings are similar with reports in previous studies showed in African region[20,30,32].

Women, who were legally married, were more likely than those living together with a sexual partners (without a legal marriage) to have higher fertility. Past studies have shown that married women have tendencies for high fertility compared to unmarried women. In a cross sectional studies conducted in Ethiopia, reported that married women were 1.62 times more likely to be at risk of high fertility compared to those who were not in union[28].

According to the theory of opportunity cost, women participation in labour market results in lower fertility. Influence of work status depends on reward from work, education and access to fertility inhibiting methods (known as opportunity structure). Working women had more opportunity cost than non-working studied by 23. Strong effect of work status on fertility is based on the nature of work. Researchers had shown significant inverse relationship between women's work status and fertilitystudies[6,15, 23,34]. Our present study also indicates that current work status is inversely related to fertility and also playsa significant role in determination of fertility.

Table-5
Association of predictors with Children Ever Born (CEB)

	Predictors	**IRR=exp(b)**	**95% Wald Confidence Interval**	
			Lower	**Upper**
	Intercept	3.181***	2.858	3.541
Place of Residence	Cities/Towns	0.888***	0.842	0.935
	Urban Villages	0.932***	0.890	0.976
	Rural	1		
Age Group	15-19	0.301***	0.250	0.363
	20-24	0.398***	0.363	0.435
	25-29	0.573***	0.530	0.619
	30-34	0.716***	0.667	0.770
	35-39	0.853***	0.797	0.912
	40-45	0.944*	0.882	1.010
	45-49	1		
Mother's Education	Primary	0.941*	0.881	1.006
	Secondary and Higher	0.768***	0.714	0.827
	No Education	1		
Marital Status	Married	1.217***	1.153	1.285
	Living together	1.202***	1.147	1.259
	Others-Widowed, divorced	1.163***	1.067	1.267
	Never married	1		
Mother's Employment	Working	0.928***	0.889	0.968
	Not working	1		
Watch television at least once a week	Yes	.901***	0.862	0.942
	No	1		
Mothers age at her first child birth	10-14	1.759***	1.504	2.057
	15-24	1.514***	1.406	1.631
	25-39	1		
Ever used condom	Yes, ever used	0.978^{ns}	0.922	1.037
	Currently using	0.919**	0.867	0.975
	Never used	1		
	Total			

b: Estimated Poisson regression coefficient

Access to media also turned out to be a crucial determinant of fertility. Women who watched television at least once a week had lower fertility compared to those that did not watch television at all.

Respondents' age at first marriage was found to be an important determinant of the number of children that women will have in her lifetime. Similar findings have been reported by a previous study, where they acknowledged that early marriage and childbearing at young ages are associated with high fertility, however ever use of contraceptive had the significant impact on fertility reduction[1]. The findings of the present study discovered that use of condom by either partner had lower fertility than non-user of condoms.

Conclusion

Using Poisson regression modeling approach we reported the effects of possible determinants of fertility in Botswana. Clearly, societal factors have great influence on the level of fertility in Botswana. Fertility level in Botswana was found to be higher in the rural areas than in the urban areas, among the less educated and non-working women. Overall it is concluded that Poisson regression model explicitly explained the association of CEB with socioeconomic and demographic predictors.

Limitation of the Study: Among others one limitation is that this study is based on cross-sectional data so we are unable to detect causality but only association between the dependent variable and the included explanatory variables. However the results do show the predictors of fertility among Botswana women.

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