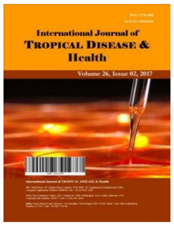

International Journal of TROPICAL DISEASE & Health

30(3): 1-12, 2018; Article no.IJTDH.40601
ISSN: 2278–1005, NLM ID: 101632866

Application of Count Models on Infant and Child Mortality in Nigeria: A Comparative Study

Kolawole S. Oritogun[1*] and Elijah A. Bamgboye[2]

[1]*Department of Community Medicine and Pry Care, Obafemi Awolowo College of Health Sciences (OACHS), Olabisi Onabanjo University, Sagamu, Nigeria.*
[2]*Department of Epidemiology and Medical Statistics, University of Ibadan, Ibadan, Nigeria.*

Authors' contributions

This work was carried out in collaboration between both authors. Authors KSO and EAB conceived and designed the study and wrote the protocol. Author KSO managed the literature searches and performed the statistical analysis. Both authors contributed to the introduction, results and discussion. Author EAB managed the analyses of the study. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJTDH/2018/40601
Editor(s):
(1) Ashlesha Kaushik, Pediatric Infectious Diseases, Unity Point Health, USA.
Reviewers:
(1) Jean Modeste Harerimana, Rwanda.
(2) S. Thenmozhi, Periyar University, India.
(3) A. Papazafiropoulou, Tzaneio General Hospital of Piraeus, Greece.
Complete Peer review History: http://www.sciencedomain.org/review-history/24452

Original Research Article

Received 3rd February 2018
Accepted 12th April 2018
Published 4th May 2018

ABSTRACT

Background: Majority of studies on determinants of Infant and Child Mortality in Nigeria were mainly analyzed using binary models such as Logistic model, Hazard Proportional model, and Probit model which categorized infant mortality as a categorical variable. However, this study is aimed at comparing count models in identifying factors associated with Infant and Child mortality in Nigeria.
Methods: This study made use of 2008 Nigeria Demographic and Health Survey (NDHS) data. This was a stratified two-stage cluster sampling design study. The models used were Poisson model (POM), Zero-Inflated Poisson model (ZIPM), Negative Binomial model (NBIM), and Zero-Inflated Negative Binomial model (ZINBIM). Model selection criteria were Akaike Information Criterion (AIC) and Lilliefors test.
Results: Results from the model comparison for infant and child mortality showed that POM and ZINBIM had the smallest AIC values of 15167.95 and 22699.48 while the p-values for Lilliefors test

**Corresponding author: Email: oritogunks@yahoo.co.uk, ksoritogun@gmail.com;*

for both models were 0.5553 and 0.3338 respectively, hence of best fit. Birth order, breastfeeding, parents' education (primary/no education), toilet type (no facility, other type apart from pit latrine) and place of delivery (home) were identified to be positively associated with associated with childhood mortality (P<0.05) while Mother's age, place of delivery (private/public hospital) and antenatal visits had negative association with childhood mortality hence experienced less child mortality.

Conclusion: Poisson model and Zero-Inflated Negative Binomial model were of best fit to model Infant and Child mortality in Nigeria respectively. Parents' education, the practice of family planning and discouragement of mixed feeding will go a long way in reducing infant and child mortality in Nigeria.

Keywords: Poisson model; lilliefors; zero-inflated models; infant and child mortality.

1. INTRODUCTION

Childhood mortality is a worldwide concern and it is regarded as an important health indicator for the measurement of standard of living of a particular country [1,2,3]. The trend of Infant mortality from 1993-1998, 1998- 2003 and 2003-2008 were 97, 99 and 75 deaths per 1000 births respectively; whereas Child mortality had 113 deaths per 1000 births, 97 and 88 for these years respectively [4]. Other mortality trends from 1999 to 2013 for Infant and child mortality were 100 and 112 (1999-2003), 75 and 88 (2004- 2008), 69 and 64 (2009- 2013) per 1000 births respectively [5]. Though there seem to be some decline over the years, however, concerted efforts are required to reduce childhood mortality. Many studies on Infant and Child mortality have been done both in Nigeria and beyond [6,7,8,9,3].

Several factors have been identified to be associated with childhood mortality such as age, zones, mothers' level of education, residence and wealth quintile have been shown to be associated with childhood mortality [4]. Studies have also shown that being illiterate, living in rural areas, birth intervals of less than two years, place of birth, region of residence and distance to health facilities, ever used family planning methods, had visited a health facility, utilized antenatal care for the last pregnancy, and coming from female-headed households were less likely to experience mortality than their comparison group experienced significant high mortality rate [10,6,11,12,13]. In addition, current age, breastfeeding status and birth order were highly significant factors both in infant and child mortality but socio-economic factors such as occupation and socioeconomic status showed a significant effect only on child mortality. In addition, postponing another child (for a birth interval of 5 years and above) and proper spacing of births had a noticeable effect in reducing the level of mortality [14].

Sometimes the factors associated with a particular response variable are determined by the model used, especially in comparative studies where different models are considered as was found in Log Gaussian and Gamma model on child mortality [8]. Log Gaussian model was of a better fit than Gamma model. Mother's age, place of residence, religion, the gender of infant, place of delivery and immunization had no significant effect on infant mortality while breastfeeding in log Gaussian had significant positive association [8]. On the other hand, mother's age, place of delivery and breastfeeding had a significant positive association with infant mortality in Gamma model [8]. Majority of the studies on child mortality used Categorical Models such as Multivariate Logistic regression or logit model and Cox regression models which collapses the response (infant mortality) variable into a dichotomous variable (death/alive). This approach may result in loss of information and this may lower the statistical power of the model as opposed to treating the response variable as a count data (i.e. number of infant death or child death) [15,16]. The use of count data models such as Poisson, Zero-Inflated Poisson, Negative binomial and Zero-Inflated Negative binomial use the true values of response variable without collapsing the values as in the categorical response variable. This study, therefore, seeks to apply Poisson models to Infant and Child mortality data in Nigeria at the level of count data (number of children that died per woman), which preserves the power of the statistical analysis. This will enable us to explore the true distribution of data on Infant and child mortality in Nigeria, and identify the best model that describes Infant and Child mortality in the country, using data from previous studies where categorical regression models had been used.

2. MATERIALS AND METHODS

The study was carried out in Nigeria. The country consists of 36 autonomous states and the Federal Capital Territory (FCT) in Abuja. The country shares land borders with the Republic of Benin to the west, Chad and Cameroon to the east, Niger to the north and the Gulf of Guinea on the Atlantic Ocean in the south. There are over 500 ethnic groups in Nigeria of which the three largest ethnic groups are the Hausa, Igbo and Yoruba [17,18].

2.1 Study Design /Data collection

This study used the dataset from the National survey of the 2008 Nigeria Demographic and Health Survey (NDHS). The study design and data collection are given in previous reports [1,2,4,19].

2.2 Data Analysis

The data analyses were carried out using R Statistical package. The models considered were: Poisson model (POM), Negative binomial model (NBIM), Zero-inflated Poisson model (ZIPM), and Zero-inflated Negative Binomial model (ZINBIM). The model selection criteria were Akaike Information Criterion (AIC) and Lilliefors normality test. The level of statistical error was set to be 5%. The outcome variables are a number of infants (0-11 months) and Children (12- 59 months) that died per woman. The independent variables are: Birth order number, Age of respondents, Breastfeeding or not (0= No,1=Yes), Partner's education (0=pry/no edu,1= secondary,2=Higher), Respondent's education (0=pry/no edu,1= secondary,2=Higher), Type of toilet facility (0= no facility,1= Flush,2= pit latrine,3= others), Religion (0= Traditionalist/others,1= Catholic,2= Other Christian,3= Islam), Place of delivery (0=Home,1=Private,2=Govt/Public), Antenatal visits (0= No,1= Yes).

The models for this study are: [20,21].

1. Poisson (PO) Model:

The probability for Poisson is

$$\Pr\{Q,\lambda\} = f(q;\lambda) = \frac{e^{-\lambda}\lambda^{q}}{q!} \quad \textit{for } q = 0,1,2,... \tag{1}$$

Where $\lambda > 0$. The mean and variance are equal.

Showing $$E(Q) = \text{var}(Q) = \lambda, \tag{2}$$

Having a link function $\eta_i = \log(\lambda_i)$ and

$$\eta_i = X_i^{'}\beta \tag{3}$$

The natural logarithm of the above equation is used to define the link function:

$$\log(\lambda_i) = X'\beta \tag{4}$$
$$= \beta_1 x_{i1} + \dots + \beta_p x_{ip}$$

Where $x = (x_1,...,x_k)'$ is a vector of explanatory variables or independent variables as are listed in the study? Where β_o is the intercept parameter, and β is the vector of slope parameters.

2. Negative Binomial (NBI) Model:

Negative binomial model is used when the property of Poisson model of equal mean and variance do not hold any longer. In this case, there is over-dispersion, where the variance exceeds the mean.

$$E(Q) = \lambda, \text{var}(Q) > E(Q) \tag{5}$$

Systematic part: $$= \beta_0 + \beta_i X_{ij} \tag{6}$$

Link function = log

The model:

$$Y_{ij} = \mu_{ij}\varepsilon_{ij} = \underbrace{\exp[\beta_0 + \beta_i X_{ij}]}_{Poisson} \underbrace{\varepsilon_{ij}}_{Gamma} \tag{7}$$

3. Zero-inflated Poisson (ZIP) Model :

Zero-inflated Poisson model is a mixture model of two components consisting of standard Poisson process and the logit for zero values.

For variable y, the ZIP model is

$$\Pr(y_i / x_i) = \begin{cases} \rho_i + (1-\rho_i)\exp(-\mu_i), & y_i = 0, \quad 0 \le \rho \le 1. \\ (1-\rho_i)\exp(-\mu_i)\,\mu_i^{y_i} / y_i!\ , & y_i > 0, \end{cases} \tag{8}$$

In equation (8), ρ_i represent the probability of the presence of extra zeros.

$$E(Y) = (1\text{-}\rho)\mu = \lambda, \tag{9}$$

$$\mathrm{var}(Y) = \lambda + \left(\frac{\rho}{1-\rho}\right)\lambda^2 \tag{10}$$

4. Zero-inflated Negative Binomial (ZINBI) Model

For dependent variable y_i with many zeros, ZINBI is another method that was also used for analysis in this study.

The ZINBI regression model is as follows :

$$\Pr(y_i / x_i) = \begin{cases} \rho_i + (1-\rho_i)(1+\alpha\mu_i)^{-\alpha^{-1}}, & y_i = 0, \quad 0 \le \rho \le 1. \\ (1-\rho_i)\dfrac{\Gamma(y_i + 1/\alpha)(\alpha\mu_i)^{y_i}}{y_i!\,\Gamma(1/\alpha)(1+\alpha\mu_i)^{y_i+\frac{1}{\alpha}}}\ , & y_i > 0. \end{cases} \tag{11}$$

The parameters ρ_i and μ_i depend on the covariates, where $\alpha \ge 0$ is an over-dispersion parameter.

Criteria for Model Selection

1. Akaike Information Criterion (AIC): -2L + 2P; L= log of likelihood and P= no. of parameters. [22]. (Anon. Wikipedia, 2011, 2012 AIC)
2. Lilliefors (Komogorov-Smirnov) normality test [23].

Standard normal cdf (cumulative distribution function) $\Phi(z)$ is compared with the standardized sample cdf $s(z)$ based on the transformation

$$Z_i = \frac{x_i - s_m}{s} ,$$

Where $s_m = \text{sample mean}$, s = estimate of population standard deviation.

The relations:

$\Phi(z_i) - S(z_i)$ *and* $\Phi(z_i) - S(z_{i-1})$ are used for Lilliefors test statistic.

The model with a p-value greater than 0.05 (p> 0.05) for Lilliefors test statistic and smallest AIC was selected to be of best fit.

3. RESULTS

The results of model comparison for infant and child mortality are given in Table 1.

The AIC values under Infant mortality for Poisson model (POM), Zero-Inflated Poisson model (ZIPM), Negative Binomial model (NBIM) and Zero-Inflated Negative Binomial model (ZINBIM) were 15167.95, 15169.95, 15105.42 and 15107.42 respectively with their Lilliefors p-value for normality test as shown in Table 1. POM had the Lilliefors p-value for normality test of 0.5553 (p>0.05) with the smallest AIC value of 15167.95 and hence, it is of best fit for Infant mortality. Considering Child Mortality, the AIC values for Poisson model (POM), Zero-Inflated Poisson model (ZIPM), Negative Binomial model (NBIM) and Zero-Inflated Negative Binomial model (ZINBIM) were 22854.13, 22765.75, 22708.97 and 22692.48 respectively with their Lilliefors p-value for normality test as shown in Table 1. ZINBIM had the Lilliefors p-value for normality test of 0.3338 (p>0.05) with the smallest AIC value of 22699.48 which made it to be of best fit. POM which was of the best fit for Infant Mortality identified birth order, breastfeeding, weight, women and husband education (primary/no education), toilet type (no facility, other type apart from pit latrine) and place of delivery (home) to be statistical significantly associated with infant mortality (P<0.05), Table 2. Poisson and Negative Binomial models with their Zero-Inflated models exhibit similar coefficients. ZINBIM (model of the best fit) identified all the variables except husband's education (secondary), toilet type (no facility/ another type than latrine), religion and place of delivery to be significantly associated with child mortality (P<0.05), Table 3.

3.1 Incidence Rate Ratio (IRR) for Poisson Model on Infant Mortality

The incidence rate ratios of the best models for Infant and Child mortality are shown in Table 4. The IRR results show that for every one child increase in birth order there was an increase in the expected number of children that died by

26.3%. The women and husbands whose highest education was Pry or no education experienced infant mortality 14 and 26% more than those with higher education respectively. Respondents who had pit latrine type of toilet, no toilet facility and other toilet type experienced infant mortality some 31, 27 and 32% respectively more than those who used the modern toilet. Those who delivered at home experienced 15% mortality more than those who delivered at a private hospital. However, women who breastfed their children had 90% increase in infant mortality than those who did not.

3.2 Incidence Rate Ratio (IRR) for ZINBI Model on Child Mortality

One birth increase in birth order has a 37% increase in the number of children that died while an increase in one –year in age has 0.7% decrease in the number of children that died. Breastfed children experienced mortality some 18% more than those that were not breastfed. The women and husbands' with primary/no education experienced child mortality some 75 and 26% respectively more than those with higher education, while women with secondary education increased expected number of child mortality by 40% compared with those with higher education. Furthermore, the households with another type of latrine are to increase an expected number of dead children by some 17% more than those with a modern toilet. Muslim respondents had dead children some 22% more than Catholic respondents. Women who delivered at government/public hospital had dead children some 11% less than those who delivered at the private hospital. Those who made ante-natal visits had dead children some 7% less than those who did not.

In addition, Table 5 gives the results of predicted infant mortality using Poisson model. A woman whose husband and herself had primary or no education, a Muslim, had no antenatal visits and toilet facility, delivered at home with a birth order of 6, aged 30, never breastfed would have had 1 child dead on the average (Predicted infant mortality = 1.00). A woman whose husband and herself had primary or no education, a Muslim, had no antenatal visits and toilet facility, delivered at home with a birth order of 7, aged 33, never breastfed would have had 1 child dead on the average (Predicted infant mortality = 1.28). A woman who reported 1 dead child whose husband and herself had primary or no education, a Muslim, had no antenatal visits, pit latrine, delivered at home with 2 birth order, aged 19, breastfed is to have approximately 1 dead child on the average (predicted infant death = 0.81). Also, a woman who claimed to have 3 dead children whose husband and herself had primary or no education, a Muslim, had no antenatal visits, pit latrine, delivered at home with 9 birth order, aged 40, breastfed is expected to have 4 dead children on the average (predicted infant death = 4.20)

Table 1. Model comparison using akaike's information criterion (aic) and lilliefors normality test of goodness of fit

Model	AIC	p-value for normality test
		Lilliefors
Infant mortality		
PO	15167.95	0.5553*
ZIP	15169.95	0.0008
NBI	15105.42	0.0004
ZINBI	15107.42	0.0004
Child mortality		
PO	22854.13	0.1866*
ZIP	22765.75	0.1279*
NBI	22708.97	0.0317
ZINBI	22692.48	0.3338*

**: not significant (p-value > 0.05)*

Table 2. Model estimates of the best model (Poisson) and other models for national infant mortality

Variable & intercept	POM β	ZIPM β	NBIM β	ZINBIM β
Intercept	-2.2075*	-2.2074*	-2.2279*	--2.2279*
Birth order	0.2332*	0.2332*	0.2513*	0.2513*
Respondent's age	-0.0003	-0.0003	-0.0027	-0.0026
Breastfeeding: yes	0.6397*	0.6397*	0.7008*	0.7007*
No**				
Husband's education				
Pry/no edu	0.1297*	0.1297*	0.1307*	0.1307*
Secondary	0.0189	0.0189	0.0223	0.0223
Higher**				
Respondent's education				
Pry/no edu	0.2308*	0.2307*	0.1944	0.1945
Secondary	0.0732	0.0732	0.0518	0.0518
Higher**				
Toilet type				
no facility	0.2405*	0.2404*	0.2262*	0.2262*
Pit latrine	0.2785*	0.2785*	0.2760*	0.2760*
Others	0.2728*	0.2727*	0.2676*	0.2675*
Flush**				
Religion:Islam	-0.0165	-0.0165	-0.0173	-0.0173
Traditionalist/others	-0.0616	-0.0616	-0.0936	-0.0935
Other Christians	-0.0512	-0.0512	-0.0432	-0.0433
Catholic**				
Place of delivery				
Govt/Public	0.0055	0.0055	-0.0154	-0.0153
Home	0.1389*	0.1389*	0.1336*	0.1336*
Private**				
Antenatal visits: Yes	-0.0298	-0.0299	-0.0262	-0.0262
No**				

** : significant at p-value < 0.05; ** Reference group*

Table 3. Model estimates of the best model (ZINBI) and other models for national child mortality

Variable & intercept	POM β	ZIPM β	NBIM β	ZINBIM β
Intercept	-2.5830*	-2.5678*	-2.6483*	-2.6301*
Birth order	0.2937*	0.2913*	0.3150*	0.3121*
Respondent's age	-0.0054*	-0.0046*	-0.0072*	-0.0068*
Breastfeeding: yes	0.1467*	0.1501*	0.1642*	0.1642*
No**				
Husband's education				
Pry/no edu	0.2261*	0.2170*	0.2328*	0.2288*
Secondary	0.0759	0.0690	0.0915	0.0875
Higher**				
Respondent's education				
Pry/no edu	0.5643*	0.5745*	0.5660*	0.5613*
Secondary Higher**	0.3393*	0.3457*	0.3390*	0.3393*
Toilet type				
no facility	0.0817	0.0856	0.0739	0.0770
Pit latrine	0.1586*	0.1600 *	0.1558*	0.1576*
Others	0.0942	0.1202	0.1018	0.1122

Variable & intercept	POM β	ZIPM β	NBIM β	ZINBIM β
Flush**				
Religion:Islam	0.1891*	0.1963*	0.1934 *	0.1977*
Traditionalist/others	0.0242	0.0183	0.0166	0.0150
Other Christians	0.0656	0.0697	0.0719	0.0734
Catholic**				
Place of delivery				
Govt/Public	-0.1096*	-0.1072*	-0.1151*	-0.1134*
Home	0.0812	0.0842	0.0750	0.0760
Private**				
Antenatal visits: Yes	-0.0774*	-0.0730*	-0.0681*	-0.0674*
No**				

** : significant at p-value < 0.05; ** Reference group*

Table 4. Incidence Rate Ratios (IRR) of the best models for national infant and child mortality

Variable & intercept	Infant mortality PO	Child mortality ZINBI
Intercept	0.110*	0.072*
Birth order	1.263*	1.366*
Respondent's age	1.000	0.993*
Breastfeeding: yes	1.896*	1.178*
No**		
Husband's education		
Pry/no edu	1.138*	1.257*
Secondary	1.019	1.091
Higher**		
Respondent's education		
Pry/no edu	1.260*	1.753*
Secondary	1.076	1.404*
Higher**		
Toilet type		
no facility	1.272*	1.080
Pit latrine	1.314*	1.119
Others	1.321*	1.171*
Flush**		
Religion: Islam	0.984	1.219*
Traditionalist/others	0.940	1.015
Other Christians	0.950	1.076
Catholic**		
Place of delivery		
Govt/Public	1.006	0.893*
Home	1.149*	1.079
Private**		
Antenatal visits: Yes	0.971	0.935*
No**		

** : significant at P-value < 0.05; ** Reference group*
POM: Poisson model; ZINBIM : Zero-Inflated Negative Binomial model

Table 5. Prediction of Infant mortality among the respondents

SN	Dead children	Birth order	Age	Breast feedng	Husband education	Woman's education	Toilet type	Religion	Place of delivery	Antenatal visit	Predicted mortality
1	2	6	30	no	pry/no education	pry/no education	no facility	Islam	HOME	No	1.01
2	2	7	33	no	pry/no education	pry/no education	no facility	Islam	HOME	No	1.28
3	1	3	30	no	pry/no education	pry/no education	no facility	Islam	HOME	Yes	0.49
4	1	6	33	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	1.06
5	1	2	19	yes	pry/no education	pry/no education	pit latrine	Islam	HOME	No	0.81
6	3	9	40	yes	pry/no education	pry/no education	pit latrine	Islam	HOME	No	4.20
7	2	2	17	yes	pry/no education	pry/no education	pit latrine	Islam	HOME	No	0.81
8	0	1	16	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	0.33
9	4	8	29	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	1.67
10	0	2	25	no	pry/no 20education	pry/no education	pit latrine	Islam	HOME	No	0.41
11	0	2	20	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	0.41
12	1	4	29	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	0.66
13	4	8	33	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	1.68
14	0	1	20	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	0.33
15	3	10	40	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	2.69
16	3	6	31	yes	pry/no education	pry/no education	pit latrine	Islam	HOME	No	2.07
17	2	4	22	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	0.66
18	0	6	32	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	1.05
19	0	6	32	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	1.05
20	0	1	21	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	0.33
21	2	5	26	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	0.83
22	2	9	35	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	2.12
23	2	6	28	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	1.05
24	4	8	30	no	pry/no education	pry/no education	pit latrine	Islam	HOME	No	1.60
25	0	3	28	no	pry/no education	pry/no education	no facility	Islam	HOME	No	0.5.

4. DISCUSSION

This study has identified Poisson model (POM) and Zero-inflated Negative Binomial model (ZINBIM) appropriate for modelling infant and Child mortality in Nigeria respectively. It shows that Infant mortality using the data in this study follows a Poisson distribution. This is a situation where equidispersion occurs. The expected mean is the same with the variance in the data. The use of Poisson model was similar to the study in South Africa [24]. On the other hand, the best fit model for the National child mortality data was the Zero-Inflated Negative binomial model (ZINBIM). This can be explained by the fact that the National child mortality data consists of excess zeros with overdispersion. The ZINBIM is a mixture model with the combination of Negative binomial distribution and the logit distribution while the Negative binomial is also a mixture model consisting of Poisson and Gamma distributions and so sometimes called Gamma-Poisson mixture. Thus the ZINBI model will be appropriate for modelling child mortality in Nigeria.

In this study, the education of the woman had a positive association with Infant and Mortality. Women who had no education, primary or secondary education were likely to have more Infant and Mortality than those who had higher education. The higher the level of education of the woman, the lower the risk of mortality. Educated mothers will be well informed about factors such as antenatal care, family planning and others that will lead to a reduction of Infant and child mortality. Similar results were obtained from previous studies [25,26,27,28,6, and 11].

Birth order was another important factor positively associated with Infant and child mortality. Infant and Child mortality increased as birth order increased. Birth order of greater than or equal to four (>= 4) has been said to experience significant high childhood mortality, possibly due to less care, since the woman has more children to attend [29,10,6,14,30]. More so, as the birth order increases, the age of the mother also increases. Previous work has shown that as the age of mother's increases the risk of mortality of children increases [2]. Therefore, there is the likelihood of an increase in obstetric complications as the mothers' age increases. The competition for food and other resources in the family as a result of increased birth order may predispose to malnutrition, increased morbidity, and eventually Infant and Child Mortality.

This study also revealed that types of toilet facilities were a risk factor for having Infant and Child Mortality. Women who lived in a household with pit latrine type of toilet facility or household with no facility experienced higher mortality than those who lived in a household with the flush toilet or modern toilet facilities. Having none or sub-standard toilet facilities increases Infant and Child mortality in the present study. There were similar reports where having hygienic latrines lower childhood mortality. Morbidity reduces when better sanitation facilities are put in place [25,31].

The result that women that breastfed had higher mortality than those who did not appear surprising and was unexpected despite the governmental and private organizations efforts in promoting exclusive breastfeeding. This result was similar to the work of Das R.N. that had breastfeeding to be positively associated with childhood mortality [8]. Another study found that exclusive breastfeeding of children < 4 months old, and using a combination of breastfeeding and solid foods for children of ages 7- 9 months were associated with higher mortality [32]. It is likely that some women who reported practising exclusive breastfeeding were not actually doing so. A study in Nigeria reported that exclusive breastfeeding for the first six months was poorly practised in Nigeria [4]. The use of breast milk substitutes and poor weaning practices can predispose infants to infection such as diarrhoeal diseases which can lead to increased mortality [4]. Studies have also shown that substitutes such as formula and another kind of milk are often inadequate in essential nutrients that can lead also to malnutrition which may also lead to death [5], however, some previous studies gave contrary reports to our results, stating that mothers who breastfed are more likely to experience higher childhood survival compared with those who did not [25,33,28].

Furthermore, husband education was an important factor in Infant and child mortality. Children of fathers with no education or primary education experienced higher mortality than those with secondary or higher education. The father is the breadwinner in the family, who is expected to provide for the needs of the family. Fathers' education in most cases dictates the type of job and income of the father. This also likely relates to the economic class of an individual. Those with higher education may be well informed than those with lower education on how to care (immunization knowledge, general sanitation, nutrition, antenatal, use of bed-net, hygiene etc) for their children. A similar result was obtained from the previous study that fathers' education had a significant effect on child mortality [31].

The practice of Islamic religion was associated with higher child mortality compared to being a Catholic. The increased mortality associated with child mortality could be as a result of certain practices associated with Islamic religion such as polygamy, early marriage large family size. In addition, Muslims are concentrated more in the northern part of the country which also is an important region for increased mortality [4,1,2,34]. A study has shown that Islamic religion women experienced more childhood mortality than Christians [2].

The study also showed that antenatal visits during pregnancy had a negative significant association with infant and child mortality. Hence, increased attendance at antenatal clinic reduced infant and child mortality but not significant for an infant. Studies have shown that sufficient attendance of antenatal care reduced childhood mortality [31,35]. Also, inability to attend or obtain modern health care services may probably be due to the cost of health services that will be provided [36]. Our result is similar to studies from Bangladesh that women who delivered at home are likely to experience more mortality [31,25, 35]. Another study by Fagbamigbe also recorded same [3].

The use of counts models in this study enabled us to identify the true distribution of Infant and Child Mortality in Nigeria as in ZINBIM. This model described the data for child mortality as having excess zeros and over-dispersion which is not possible with binary Logit or logistic regression that are common in the literature. This study added the advantage of count data models to predict the actual expected or average number of deaths per woman in the presence of the factors used in the model, which binary model will not be able to do. The binary model could only indicate whether there will be survival or not.

5. CONCLUSION

The study has shown that Poisson model and Zero-Inflated Negative Binomial model were the best models that described Infant and Child mortality respectively in Nigeria. Breastfeeding, type of toilet (other than flush-toilet), birth order, respondent's education (pry/no education), place of delivery (home) and husband education (pry/no education) were positively associated with Infant Mortality. Respondent's education (pry/no education and secondary), birth order, husband education (pry/no education), Religion (Islam), breastfeeding and type of toilet (pit latrine) were positively associated with Child Mortality, while Place of delivery Govt/Public health, antenatal visits and women's age had negative association with Child Mortality. The study has some policy implications such as encouraging women to exclusively breastfeed for the first six months of life and practising safe weaning practices. Improvement in the acceptance of family planning /birth spacing practices of women. Improving the sanitary environment of people and educating women are some areas that Policymakers can focus on in reducing child mortality in Nigeria.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

ACKNOWLEDGEMENT

We appreciate the ORC Macro International, and National Population Commission, Abuja, Nigeria for allowing us to use the 2008 NDHS data.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/24452