Poverty and Maternal Nutritional Status as Determinants of Weight at Birth: A Multilevel Ordinal Logistic Regression Approach

By

Samson B. Adebayo[1], Oladipupo B. Ipadeola & Jennifer Anyanti

Research and Evaluation Division

The Society for Family Health

Abuja, Nigeria

Abstract

Statistical models that consider the exhaustive categories of possible outcomes of child's weight at birth are rarely found in literature. This paper, however, explores possible influence of household poverty level and maternal nutritional status on the weight outcome at birth of children under five years. Weight at birth was measured on a five-level ordinal scale. Analysis based on traditional common regression techniques could not be employed for two reasons. Firstly, the response variable was observed on ordered categories. Secondly, household survey data often exhibit that responses of individuals that belong to the same cluster are correlated. Therefore, modelling techniques that take cognizance of ordinal responses and dependence among observations are suitable for correct inference. We analysed a dataset on child's weight at birth from the 2003 NDHS using '*svy*' command in STATA. This method produces more robust estimates of the standard errors.

Introduction

Child's weight at birth has been shown to be associated with child and maternal health which in turn could be a determining factor of maternal and child mortality before, during and after birth. This may also be related to many factors both physical and physiological. Among such factors that have been investigated in the past were maternal and paternal weights and heights, ethnicity, gestational age, birth order, maternal education, mother's age at the birth of child and race (Griffiths, Dezateaux & Cole, 2006; Fuentes-Afflick & Hessol, 1997; Xiong, Demianczuk & Saunders, 2002; Richard et al., 2001; Oken *et al.*, 2003). Other possible determinants of child's weight at birth that have been considered in literature are paternal education, socioeconomic status, prenatal care, method of delivery (either normal or through caesarean), child's sex, maternal smoking status, consumption of alcohol, and use of psychoactive drugs during pregnancy (Elter, Ay & Erenus, 2003; Fang, Madhavan & Alderman, 1999). Griffiths *et al.* (2006) observed that maternal weight had a greater influence on birth weight while maternal and paternal height contributions were similar. Furthermore, that weights and heights of father and mother contributed equally to infant's weight gain.

Birth weight is a determining factor of weight gain at birth. While low birth weight is associated with increased risk of morbidity and mortality in the newborns, overweight is associated with decreased maternal amino acid. Decreased foetal growth may result from a limitation in the nutrient supply to the foetus. Research had linked small size at birth to increased risk of heart disease and diabetes later in life. Furthermore, poverty has been shown to be a determining factor of maternal and child health.

Traditional statistical techniques assume that observations are independent. However, due to the hierarchical nature of survey data through a multi-stage selection technique, it is sometimes appropriate to assume that observations from individuals that are within the same clusters are correlated. Therefore, due to the survey design, responses can be assumed to be correlated. In this paper, we examined associations of poverty, demographic factors and weight at birth using the 2003 Nigeria Demographic and Health Survey (NDHS) data. Wealth index as contained in the 2003 NDHS data was used as a proxy measure of poverty which is similar to previous authors. For instance, Filmer & Pritchett (2001), Montgomery *et al.* (2000) considered ownership of assets as proxy to assessing wealth index.

Weight at birth was measured on a five level ordinal scale: *very small, smaller than average, average, larger than average* and *very large*. For the purpose of this analysis we condensed the categories of outcome variable into three: *small, average* and *large.* To analysis the influence of covariates such as wealth index, maternal educational attainment, mother's age at birth, maternal nutritional status, geopolitical zones where child resided during survey, etc., regression models for ordinal responses are a natural choice, see Kublin (1987). For a correct analysis we have to take into account the statistical dependence among observations within clusters, see Fahrmeir & Pritscher (1996). Therefore, modelling techniques for ordinal responses, taking cognizance of

[1] Corresponding author: sadebayo@sfhnigeria.org

dependence among observations are appropriate for correct inference. As a consequence, the '*svy*' (set at cluster level) and '*logit*' commands in STATA were combined to analyse the influence of covariates that are assumed to be related to child's weight at birth.

Data and Method

Data

The principal objective of the 2003 NDHS is to provide current and reliable data on fertility and family planning behaviour, child mortality, children's nutritional status, the utilization of maternal and child health services, and knowledge and attitudes towards HIV/AIDS. A related objective is to provide as many of these key indicators as possible for urban and rural areas separately, as well as for the six geopolitical zones in Nigeria. The population covered by the 2003 NDHS is defined as the universe of all women age 15-49 and all men age 15-59 in Nigeria. A probability sample of households was selected and all women age 15-49 identified in the households were eligible to be interviewed. In addition, in sub-sample of one-third of the households selected for the survey. All men age 15- 59 were eligible to be interviewed (NPC [Nigeria] & ORC Macro, 2004).

The sample frame for this survey was the list of enumeration areas (EAs) developed for the 1991 population census. Administratively, at the time the survey was planned, Nigeria was divided into 36 states and the federal capital territory (FCT) Abuja. Each state was divided into local government area (LGA) units and each LGA was divided into localities. In addition to these administrative units, for implementation of the 1991 population census, each locality was subdivided into enumeration areas (EAs). The list of approximately 212,080 EAs, with household and population information (from the 1991 census) for each EA was evaluated as a potential sampling frame for the 2003 NDHS. The EAs are grouped by states, by LGAs within a state, and by localities within LGA, stratified separately by urban and rural areas. Any locality with less than 20,000 populations constitutes a rural area. Also available from the 1991 census were maps showing the location of the EAs. These maps needed to be updated in the field before the final household selection. After a careful evaluation, the EA list was used as the sample frame. We used the child recode data of the 2003 NDHS for the purpose of these analyses. This was created from women with children under five during the period of the survey.

Method

Consider the regression situation where outcome variable of child's weight at birth: Y_i, i = 1, ...,n is measured on an ordinal scale. A cumulative logistic regression model is fitted. Suppose Y_i has k categories together with discrete or continuous covariates x_i. Marginal probabilities for Y_i are related to covariates x_i by a cumulative model

$$g\{pr(Y_i \le r \mid x_i)\} = \theta_r + x'\gamma, \qquad \mathrm{r = 1,...,k-1},$$

for some suitable link function g, ordered threshold parameters $\theta_1 < \ldots < \theta_{k-1}$ and a vector γ of covariate effects. A logit link function

$$\frac{p(Y_i \le r \mid x_i)}{p(Y_i > r \mid x_i)} = \exp(\theta_r + x'\beta) = \exp(\theta_r)\exp(x'_i\,\beta), \quad \mathrm{r = 1,...,k-1}. \qquad (1)$$

Details of many ordered response models are discussed in Fahrmeir & Tutz (2001). The commonly used model in the ordinal regression is based on the category boundaries or threshold approach. The parameter β refers to the effect of x_i on the log odds that Y_i, controlling for the other covariates.

In our application of weight at birth, the response variable

$$Y_i = \begin{cases} 1: \text{if child's weight at birth is small} \\ 2: \text{if child's weight at birth is average} \\ 3: \text{if child's weight is large} \end{cases} \qquad (2)$$

was developed. It is worth noting that though the NDHS data have a variable that asks about the actual weight of child at birth. However, due to poor recall rate from mothers we used a proxy variable that permitted mothers to describe child's weight in terms of *very small, smaller than average, average, larger than average and very large*. Information on this was missing in about 1.8% of the respondents. This is tolerable enough to permit reasonable analysis. Furthermore, there was no clear-cut pattern of missingness. All covariates were dummy coded including mother's age at birth and maternal nutritional status which were originally measured on continuous scale. All analyses were done with '*svy:ologit*' command in STATA SE 9.2. This command provides more robust estimates of standard errors.

Discussion of Results

Table 1 presents findings from both models that consider naive and robust estimates of standard errors. Comparing the two results, odds ratios from respective point estimates of regression coefficients are similar. However, (naive) standard errors from ordinary ordinal logistic regression model are distinctly smaller than the robust estimates of standard errors. Therefore, naive estimation will lead to over-interpretation of results. For instance, one would have falsely considered the effect of 'obese' (OR=1.35, p=0.028) as statistically significant.

Henceforth, we shall base all interpretations on the model with robust estimates. Significant and positive association was evident with poorest (OR=0.72, p<0.0001), poorer (OR=0.81, p=0.016), richer (OR=1.1, p=0.496), richest (OR=0.99, p=0.895). Respondents in the poorest and poorer levels are less likely to give birth to children with large weight compared with those in the middle class (significant as p<0.05) while those in the upper class are more likely to give birth to children with large weight compared with those in the middle class (not significant). Significant gender differential was also found as males are about 1.4 times (p<0.0001) more likely to have large weight at birth compared with their female counterparts. Mothers that were underweight based on their BMI, are less likely to give birth to children with large weights (OR=0.804, p=0.015); while those that were overweight (OR=1.37, p<0.005) or obese (OR=1.28, p=0.065) are more likely to give birth to children with high weight compared with mothers in the normal BMI. Teenage mothers are less likely to give birth to children with high birth weight (OR=0.81, p=0.01). Though positive association was observed for mothers in other categories, however the effects are not significant. We need to point out here that significant spatial pattern is observed at the level of geopolitical zones with p<0.05 except in the South South. This, however, needs to be investigated further at a highly disaggregated level of state as information at zonal level could be masked.

Conclusion

This approach has provided us opportunity of exploring relationship of ordinal responses on determinants of child's weight at birth by considering an approach that utilizes robust estimates of standard errors. Wealth index and maternal nutritional status were found to be significantly associated with child's weight at birth. Female children were disproportionately associated with low birth weight. Findings from this paper will provide opportunity to enhance appropriate policy formulation.

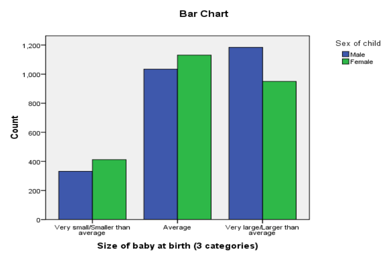
Table 1: Descriptive information about the Determinants of child's weight at birth

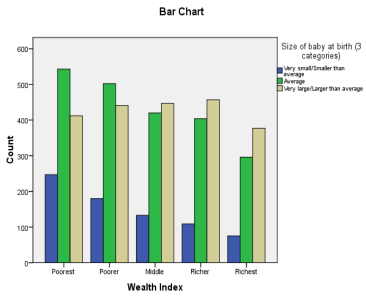
Variables	Ologit output			Suvlogit output		
	odds ratio	Std. error	p-value	odds ratio	Std. error	p-value
Poorest	0.720	0.063	0.000	0.720	0.091	0.009
Poorer	0.796	0.069	0.008	0.796	0.041	0.066
Richer	1.023	0.095	0.808	1.023	0.115	0.841
Richest	0.933	0.109	0.554	0.933	0.140	0.646
Urban	1.006	0.071	0.933	1.006	0.100	0.952
Primary Educ.	1.089	0.085	0.272	1.089	0.105	0.377
Secondary Educ.	1.050	0.104	0.617	1.050	0.121	0.669
Higher Educ.	1.210	0.231	0.317	1.210	0.2301	0.316
Partner primary education	1.109	0.086	0.180	1.109	0.104	0.270
Partner secondary educ.	1.285	0.110	0.004	1.285	0.122	0.009
Partner higher education	1.129	0.131	0.297	1.129	0.128	0.285
S. South	0.946	0.129	0.686	0.946	0.159	0.743
N. East	0.623	0.076	0.000	0.623	0.100	0.004
N. West	0.568	0.069	0.000	0.568	0.090	0.000
S. East	1.484	0.181	0.001	1.484	0.245	0.017
S. West	0.553	0.077	0.000	0.553	0.090	0.000
Male	1.389	0.077	0.000	1.389	0.081	0.000
Underweight	0.816	0.069	0.017	0.816	0.074	0.025
Overweight	1.366	0.114	0.000	1.366	0.123	0.001

Obese	1.350	0.185	0.028	1.350	0.207	0.051
MAB* (Below20years)	0.777	0.063	0.002	0.777	0.069	0.005
MAB (20-24 years)	0.913	0.063	0.187	0.913	0.070	0.236
MAB (35-39 years)	1.005	0.099	0.957	1.005	0.109	0.961
MAB (40-49 years)	0.930	0.134	0.476	0.930	0.162	0.676
Threshold 1	-1.881	0.146		-1.881	0.184	
Threshold 2	0.295	0.143		0.295	0.179	

* MAB - Mother's age at birth

Figure 1: Child's size at birth by sex and wealth index





References

1. Elter, K., Ay, E. & Erenus, M. (2003): Does Birth Weight affect Mode of Delivery? *European Journal of Obstetrics & Gynecology and Reproductive Biology*, 111(2): 221.
2. Fahrmeir, L. & Pritscher, L. (199?): Regression Analysis of Forest Damage by Marginal Models for Correlated Ordinal Responses.
3. Fahrmeir, L. & Tutz, G. (2001): *Multivariate Statistical Modelling based on Generalized Linear Models (3rd edition)*, Springer, New York.
4. Fang J., Madhavan, S. & Alderman, M. (1999): Low Birth Weight: Race and Maternal Nativity – Impact of Community Income. *Pediatrics,* 103(1).
5. Filmer, D. & Pritchett, L.H. (2001): Estimating Wealth Effects without Expenditure Data-or Tears: An Application to Educational Enrolments in States of India *Demography,* 38(1):115-132.
6. Fuentes-Afflick, E. & Hessol, N.A. (1997): Impact of Asian Ethnicity and National Origin on Infant Birth Weight. *American Journal of Epidemiology*, 145:148-55.
7. Griffiths, J.L., Dezateaux, C. & Cole, T.J. (2007): Differential parental weight and height contributions to offspring birth weight and weight gain in infancy. *International Journal of Epidemiology*, 36(1):104-107.
8. Montgomery, M.R., Gragnolati, M., Burke, K.A. & Paredes, E. (2000): Measuring Living Standards with Proxy Variables. *Demography,* 37(2):155-174.
9. National Population Commission (NPC) [Nigeria] & ORC Macro (2004): *Nigeria Demographic and Health Survey 2003*. Calverton, Maryland: National Population Commission and ORC Macro.
10. Oken, E., Kleinman, P.K., Rich-Edwards, J. & Gillman, M.W. (2003): *BMC Pediatrics* 3:6doi:10.1186/1471-2431-3-6.
11. Richard, M, Hardy, R., Kuh, D. & Wardsworth, M.E.J. (2001): Birth weight and cognitive function in the British 1946 birth cohort: Longitudinal population based study. *BMJ*, 322:199-203.
12. Xiong, X., Demianczuk, N.N., Saunders, D.L., Wang, F.L. & Fraser, D.W. (2002): Impact of Preeclampsia and Gestational Hypertension on Birth Weight by Gestational Age. *American Journal of Epidemiology*, 155:203-209.