Effect of low birth weight on infant mortality: Analysis Using Weibull Hazard Model

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Abstract

Aim: To examine the relationship between high-risk infant of born with low birth weight and infant mortality in Nigeria

Methods: The relationship between low birth weight and infant mortality was examined using multivariate survival regression procedure with Weibull hazard function, controlling for child's sex, birth order, prenatal care, delivery assistance; mother's age at child birth, nutritional status, education level; and household living conditions.

Results: Results indicate that children with low birthweight were more than 37 times more likely to die during infancy compared to those born with normal weight (hazard ratio = 1.37; 95% confidence interval: 1.09, 1.72) holding other factors constant.

Conclusions: Low birth weight is strongly negatively associated with infant survival in Nigeria independent of other risk factors. Children can be ensured a healthy start in life if women start pregnancy healthy and well nourished, and go through pregnancy and childbirth safely.

INTRODUCTION

More than 20 million infants worldwide, representing 15.5 per cent of all births, are born with low birth weight, 95.6 per cent of them in developing countries[1]. The level of low birth weight in developing countries (16.5 per cent) is more than double the level in developed regions (7 per cent)[1]. Birth weight is a strong indicator not only of a birth mother's health and nutritional status but also a newborn's chances for survival, growth, long-term health and psychosocial development [2]. A low birth weight (less than 2,500 grams) raises grave health risks for children [2]. Babies who are undernourished in the womb face a greatly increased risk of dying during their early months and years[2]. This is based on epidemiological observations that infants weighing less than 2,500 g are approximately 20 times more likely to die than heavier babies. More common in developing than developed countries, a birth weight below 2,500 g contributes to a range of poor health outcomes. Those who survive have impaired immune function and increased risk of disease; they are likely to remain undernourished, with reduced muscle strength, throughout their lives, and to suffer a higher incidence of diabetes and heart disease[2]. Children born underweight also tend to have cognitive disabilities and a lower IQ, affecting their performance in school and their job opportunities as adults. Previous studies have also linked infant mortality with mother's education, age at childbirth, delivery status, health status, parity and marital union; father's education and employment; household income and consumer goods, household safe source of drinking water and sanitation; and slum and rural residence [3,4,5]. Demographic characteristics such as child's sex, ethnicity, preceding and succeeding birth interval, and birth order are also known to be associated with infant mortality[6]. However, little research has been done in developing countries to examine the association low birth weight and infant mortality. Using data from the 2003 Nigeria Demographic and Health Survey, this study examines if infants born with low birthweight have disproportionately higher risk of mortality than infants born with normal weight.

METHODS

DATA SOURCE

This study uses data from the 2003 Nigeria DHS. It is based on information of 5783 children born within five years prior

to the survey. The NDHS collected demographic, socio-economic, and health data from nationally-representative sample of 7620 women aged 15-49 years in 7864 households included in the survey. The state was stratified into 36 states and the Federal Capital Territory (FCT) of Abuja within the six geopolitical regions. Each domain is made up of enumeration areas (EAs) established by a general population and housing census in 1991. The sampling frame was a list of all EAs (clusters). Within each domain, a two-stage sample was selected. The first stage involved selecting 466 clusters (primary sampling units) with a probability proportional to the size, the size being the number of households in the cluster. The second stage involved the systematic sampling of households from the selected clusters.

VARIABLES

Each woman interviewed in the survey was asked to provide a detailed history of all her live births in chronological order, including child size at birth, sex of the child, date of birth, survival status, age of the child on the date of interview if alive, and if not alive, age at death of each live birth. These data from the birth histories were used to calculate infant mortality rate, defined as the probability of dying before completing 12 months of age, using a synthetic cohort life table[$_7$]. The rate is expressed as deaths per 1000 live births. NDHS also includes a household wealth index estimated from several durable household assets and household economic level is measured by dividing the wealth index into quintiles. The main explanatory variable of interest in this study is child birth weight. This was assessed by asking the mother about size of child at birth. The possible outcomes for this question are very large, larger than average, average, smaller than average, and very small. This was dichotomized into two groups, with smaller than average and very small forming one group of dichotomy.

Because child survival is correlated with pregnancy care, delivery assistance, maternal nutrition, household living conditions, and other child, mother, and household characteristics and socio-economic factors that can also affect morbidity and mortality in children, the association of birth weight and infant mortality are estimated after adjusting for the effects of these other risk factors and potentially confounding factors (berkman). These factors include child's sex (boy, girl), professional assistance at delivery (no, yes), birth order (1, 2, 3, 4+), mother's age at childbirth (13–24, 25–34, 35–48), mother's body mass index (BMI) (<18.5, 18.5–24.9, 25.0+ kg/m2), mother's education (no education, some primary, secondary or higher), household wealth index (highest, fourth, middle, second, lowest), household access to safe drinking water (yes, no), availability of a hygienic toilet (yes, no), cooking fuel type (low pollution fuel, high pollution fuel), ethnic group (hausa/fulania, igbo, Yoruba, others) residence (urban, rural) and geographic division (North central, North East, North West, South East, South South, and South West).

STATISTICAL ANALYSIS

Relationship of low birth weight and other factors on infant mortality were estimated using multivariate survival regression procedure with Weibull hazard function in Stata version 10 [$_8$]. A number of unadjusted hazard regression models were used to assess the unadjusted effect of low birth weight and different risk factor and confounding factor, and a full adjusted model to assess the adjusted effect of low birth weight controlling for all other factors that were significant in the unadjusted analyses ($p < .05$). In our analysis, weights were used to restore the representativeness of the sample, in which certain categories of respondents were over-sampled and non-response rates varied from one geographical area to another. Results are presented as hazard ratios (HR) with 95% confidence intervals (CI).

ETHICS

This study is based on an analysis of existing survey data with all identifier information removed. The Ethics approved the survey Committee of the ORC Macro at Calverton in the USA and by the National Ethics Committee in the Ministry of Health in Nigeria. All study participants gave informed consent before participation and all information was collected confidentially.

RESULTS

Table 1 shows the sample distribution of children born in the five years preceding the NDHS by self-reported birth weight and other selected characteristics. About 14% of children are low birth weight as reported b their mothers.

Figure 1

Table 1: Sample distribution and infant mortality rate (IMR) among children born during 1999 – 2003 by household wealth status and other selected characteristics, Nigeria 2004

Characteristics	*Weighted sample*	*Sample distribution (%)*	*IMR per 1000 Live births*
Nigeria	6219		100.8
Low birth weight			
No	5315	85.5	94.6
Yes	904	14.5	137.9
Child's sex			
Girl	3033	48.8	94.9
Boy	3186	51.2	106.6
Delivery by a health care professional			
No	4151	66.7	109.3
Yes	2025	32.6	73.0
Child's birth size			
Small size	904	14.5	137.9
Average size	2548	41.0	92.9
Large size	2686	43.2	58.9
Child's birth order			
1	1278	20.6	115.6
2	1001	16.1	76.5
3	907	14.6	89.7
4+	3032	48.8	106.5
Mother's age at childbirth			
13 – 24	2822	45.4	106.2
25 – 34	2505	40.3	91.2
35 – 48	892	14.3	110.8
Mother's BMI (kg/m²)			
18.5 – 24.9	4004	64.4	104.8
< 18.5	773	12.4	91.7
≥ 25	1305	21.0	91.8
Mother's education level			
No education	3224	51.8	115.3
Primary	1465	23.6	108.4
Secondary or higher	1530	24.6	64.6
Household economic status			
Poorest	1394	22.4	128.7
Poor	1379	22.2	136.5
Rich	1255	20.2	96.5
Richer	1157	18.6	70.1
Richest	1033	16.6	53.3
Hygienic toilet			
No	5436	87.4	107.7
Yes	782	12.6	50.0
Safe water source			
No	4597	73.9	107.2
Yes	1620	26.1	83.1
Cooking fuel			
Low pollution fuel	4934	79.3	107.0
High pollution fuel	1174	18.9	68.9
Type of residence			
Urban	1795	28.9	75.6
Rural	4424	71.1	114.5

Consistent with higher fertility in the poorer households, 44% of children were born in the poorest 40% households, and 17% were born in the richest 20% households. Fifty-one percent of all births were boys and 49% were girls. About one third received professional assistance at delivery. Only 12% of the births were to undernourished mothers (BMI < 18.5 kg/m2), more than half (51%) of the births were to illiterate mothers. About 26% of children were born in households with safe sources of drinking water, 87% were in households without a hygienic toilet facility, and 79% were in households using high pollution fuels (firewood or straw) for cooking. Seventy-one per cent of births were in rural areas. Twenty-one per cent of children were first order births, and 49% were fourth or higher order births. Almost half (45%) of the births were to mothers aged 13–24 years, about 40% were to mothers aged 25–34 years, and the remaining 14% to mothers aged 35–48 years. By geographic division, more than one-third (35%) of the births were in North West, 24% were in North east, 14% were in North central, 13% were in South south, 8.5% were in South south, and only 6% were in South east

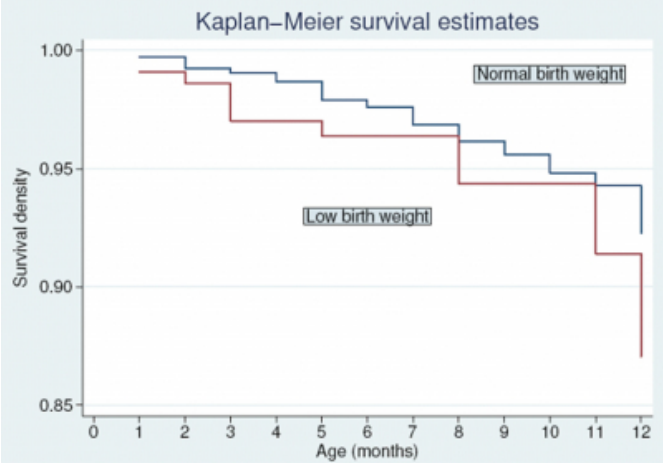
On average, more than one in every 10 children born in Nigeria (101 per 1000 live births) does not survive to their first birthday. The infant mortality rate is very high among the children with low birth weight – 138 per 1000 live births compared with 95 per 1000 live births among the children born with normal weight. The infant mortality rate is higher among boys (107) than among girls (95). The probability of death before 12 months of age for children born in the poorest 20% households is greater than children born in the richest 20% households. Household lacks of a hygienic toilet facility and non-availability of safe drinking water were associated with higher risk of infant mortality. Infant mortality rate is higher in rural area than in urban area; and it is considerable higher in North east than other geographical divisions.

ASSOCIATION OF LOW BIRTHWEIGHT AND INFANT SURVIVAL

For children born in the five years preceding the NDHS, the survival probabilities for children born with low birth and average or large than average singleton by single months of age before 12 months is presented in Figure 1. The difference in survival probability between children born average (or larger) and smaller than average was non-random as judge by log-rank test of survival functions (?2 [$_1$] =8.56; p=.003).

Figure 2

Figure 1: Probability of survival before 12 months of age by birthweight status, Nigeria 2003.



The unadjusted hazard ratio (HR) for the effect of low birth weight indicates that there is a strong positive relationship between low birth weight and infant mortality (Table 2).

Figure 3

Table 2: Unadjusted and adjusted hazard ratio estimates the risk of low birthweight mortality before 12 months of age, controlling for several factors among children during 1999 – 2003, Nigeria 2004

	Unadjusted model	*Adjusted model*
	HR [95% CI]	HR [95% CI]
Low birth weight		
Yes (versus No)	1.40 [1.12, 1.74]**	1.37 [1.09, 1.72]**
Child's sex		
Boy (versus girl)	0.89 [0.76, 1.06]	ni
Delivery by a health care professional		
Yes (versus No)	0.46 [0.37, 0.57]***	0.88 [0.67, 1.15]
Child's birth order		
1	reference	
2	0.86 [0.64, 1.15]	Ni
3	1.03 [0.77, 1.37]	Ni
4+	1.12 [0.90, 1.41]	Ni
Mother's age at childbirth		
13 – 24	Reference	
25 – 34	0.84 [0.69, 1.01]	Ni
35 – 48	1.12 [0.88, 1.42]	Ni
Mother's BMI [kg/m²]		
18.5 – 24.9	reference*	Reference
< 18.5	0.96 [0.74, 1.24]	0.87 [0.65, 1.12]
≥ 25	0.70 [0.55, 0.88]	0.97 [0.75, 1.25]
Mother's education level		
No education	reference***	Reference**
Primary	0.80 [0.66, 0.98]	0.92 [0.72, 1.16]
Secondary or higher	0.36 [0.28, 0.47]	0.51 [0.36, 0.73]
Household economic status		
Poorest	Reference***	Reference
Poor	1.03 [0.83, 1.28]	1.29 [0.80, 1.29]
Rich	0.75 [0.59, 0.96]	0.88 [0.67, 1.15]
Richer	0.52 [0.40, 0.69]	0.69 [0.48, 0.98]
Richest	0.34 [0.25, 0.48]	0.89 [0.48, 1.68]
Hygienic toilet		
Yes (versus No)	0.36 [0.25, 0.53]***	0.65 [0.39, 1.06]
Safe water source		
Yes (versus No)	0.66 [0.53, 0.81]***	0.91 [0.70, 1.17]
Low Pollution cooking fuel		
Yes (versus No)	0.44 [0.33, 0.59]***	1.13 [0.69, 1.87]
Type of residence		
Rural (versus urban)	1.74 [1.43, 2.12]***	1.15 [0.89, 1.47]
Ethnicity		
Hausa / Fulani	reference***	Reference
Igbo	0.42 [0.30, 0.60]	0.61 [0.28, 1.30]
Yoruba	0.40 [0.27, 0.58]	0.90 [0.47, 1.73]
Others	0.79 [0.66, 0.94]	0.95 [0.73, 1.23]
Region		
North central	reference***	Reference
North east	1.50 [1.15, 1.96]	1.21 [0.90, 1.64]
North west	1.49 [1.15, 1.93]	1.14 [0.80, 1.61]
South east	0.72 [0.47, 1.11]	0.61 [0.24, 1.53]
South south	1.10 [0.76, 1.58]	1.47 [1.00, 2.17]
South west	0.60 [0.39, 0.92]	0.77 [0.43, 1.39]

*P <0.05; **P <0.01; ***P <0.001
ni – not included

Children born with low birth weight are 40% more likely to die in infancy compared to those born with normal weight. (HR = 1.40; 95% CI: 1.12, 1.74). The Unadjusted models show that the infant mortality are significantly negatively associated with , delivery by a health-care professional, mother's BMI, mother's education, safe source of drinking water, hygienic toilet facility, type of fuel used for cooking, urban/rural residence and geographic division. In the adjusted model, when all characteristics of the child and mother, household wealth status, availability of safe drinking water, availability of a hygienic toilet facility, type of fuel used for cooking, urban/rural residence and geographic divisions were controlled for, the relationship of low birth

weight and infant mortality remains significant. With all child, maternal, household and other factors controlled, children born with low birth weight are 37% more likely to die in the first year of life than those born with normal weight (HR = 1.37; 95% CI: 1.09, 1.72).

EFFECTS OF OTHER RISK FACTORS AND CONFOUNDERS ON INFANT SURVIVAL

In the adjusted model (Table 2), with low birthweight status and other factors controlled, children born to mothers with secondary education or more are less likely to die before reaching their first birthday than children of mothers with no education (HR = 0.51; 95% CI: 0.36, 0.73). Compared to children from the poorest households, infant from the richer households are less likely to die before their first birthday (HR 0.69; 95% CI: 0.48, 0.98). None of the other risk factors or confounders has a statistically significant effect on the risk of infant mortality.

DISCUSSION

Results of this study support claims that children born with low birth weight are more likely to die during the first year of life as children born with normal weight, independent of child's sex, birth order, pregnancy care and delivery care, maternal education and nutritional status, household access to clean water and sanitation, and other factors. This association has been observed not only in developing countries [9,10,11,12,13,14,15,16] but also in developed countries [17,18,19,20].

This and previous studies [3,16,21,22,23,24,25] have provided evidence that children born in the poorer households are a much greater risk of dying in infancy than children born in better-off households. Mothers in deprived socio-economic conditions frequently have low birth weight infants [1]. In those settings, the infant's low birth weight stems primarily from the mother's poor nutrition and health over a long period of time, including during pregnancy, the high prevalence of specific and non-specific infections, or from pregnancy complications underpinned by poverty [1]. Physically demanding work during pregnancy also contributes to poor foetal growth [1]. Various determinants of preterm birth and low birth weight have been described in the literature, including maternal health variables [26,27], attributes of the psychosocial context [28], and environmental exposures [5]. One of the most consistent findings of research in this area is the relationship between economic disadvantage and elevated risk for poor birth outcomes.

Consistent with previous studies [29,30,31,32,33], this study finds that mother's education has strong negative effect on infant mortality, independent of other factors. There is a very large literature from around the world that demonstrates the significance of mother's schooling to lower mortality outcome among children. The pathways from mother's schooling lower mortality rate include, but are not limited to, greater likelihood of obtaining pre- and ante-natal care, seeking prompt medical care at the first sign of a child's illness, and more appropriate breast feeding and nutritional supplementary practices.

POLICY IMPLICATIONS

Preterm birth and low birthweight remain high priority public health issues that are associated with heightened risk of infant mortality as well as subsequent health and developmental problems. The goal of reducing low birth weight incidence by at least one third between 2000 and 2010 is one of the major goals in ‘A World Fit for Children', the Declaration and Plan of Action adopted by the United Nations General Assembly Special Session on Children in 2002. The reduction of low birth weight also forms an important contribution to the Millennium Development Goal (MDG) for reducing child mortality. Activities towards the achievement of the MDGs will need to ensure a healthy start in life for children by making certain that women commence pregnancy healthy and well nourished, and go through pregnancy and childbirth safely. It is widely accepted that the ultimate outcome of infants with low birth weight closely reflects the organisation of perinatal services and the quality of neonatal intensive care [34]. There is a need for provision of to ensure access to health care services for the poor and vulnerable the government may be introduced fee exemptions. As recommended by WHO and UNICEF, all babies are weighed at birth [1,2]. The weight should be recorded on the newborn's health record for later use in monitoring the baby's growth.

STUDY LIMITATIONS AND STRENGTHS

Finally, it is necessary to discuss the limitations of this study, as well as its strengths. The present study was performed in a large nationally representative sample with stratified random sampling. The first potential limitation of this study is the cross-sectional nature of the analysis and hence the directional of casualty cannot be established. The study uses censored, synthetic cohort life table based on the birth history of children and reported characteristics of mothers and households. While some of the covariates used in our analysis, such as child's sex, antenatal care, mother's

age at childbirth are fixed covariates, others, such as mother's education, household access to clean water and sanitation, and urban/rural residence could have changed during the last 5 years. In the analysis, all covariates are assumed to have been fixed during the study period. However, because the household characteristics and many of the other background characteristics are not likely to have changed much in the past 5 years and because the main finding in the analysis is relationship of birthweight status and child survival, the cross-sectional effects estimated in these studies are good measures of child survival among low birthweight infants. Another potential limitation is reliance on self-reported birth weight. The birth weight of a baby is a good indicator of the health status of the child at birth, but many children in sub-Saharan Africa are not weighed at birth [$_{24}$]. Consequently, the mother's report of the size of the baby at birth is used as a proxy. Not all the reports from the mothers may be accurate since some mothers may report more small babies among children who are failing to thrive or those who have died, thus exaggerating the association between small size and mortality. A check of the mothers' reports of the size of the baby at birth against the birth weight where it was available revealed that in general, the mothers' reports were consistent with the recorded birth weights. Similar checks using data from Kenya have shown consistency between birth weights and mother's reports [$_{35}$]. Another limitation of this study worth mentioning is that measuring wealth is problematic. Many of the household wealth indices use assets that are more likely to be found in urban areas than in rural areas. Thus, most of the rural households will be in the lowest wealth category even if they have other indicators of wealth (e.g., livestock or farm machinery). The consequence of this misclassification would be to lower the mortality risks of rural households. Another limitation with household wealth indices derived from DHS is that they are based on current status data so that they might not capture the true level of household wealth during the infancy of children born several years before the survey. However, since these analyses are restricted to births within five years of the surveys, this bias will not be substantial.

CONCLUSIONS

In summary, children born with low birthweight are more likely to die during the first year of life compare to children born with normal weight, independent of child's sex, birth order, pregnancy care and delivery care, maternal education and nutritional status, household access to clean water and sanitation, and other factors. To improve child survival in Nigeria especially among children born with low birthweight there is a need for scaling up public health interventions at the community level, specifically screening for high-risk neonates born with low birthweight and preterm, and making referral services more readily available and accessible. Children can be ensured a healthy start in life if women start pregnancy healthy and well nourished, and go through pregnancy and childbirth safely.

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