Why are Neonates Dying? Socioeconomic and Proximate Determinants of Neonatal Mortality among Stable Low-Birth-Weight (LBW) Infants in Kenya

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Abstract

Background: Neonatal mortality rates are very high in Kenya, like the rest of Sub-Saharan Africa. The sustainable development goals aim to reduce the current 21 neonatal deaths per 1,000 live births to below 12 deaths per 1,000 live births. The rate of decline in Neonatal mortality in many countries is very slow compared to other childhood mortality rates. The objective of this study was to determine the socioeconomic and proximate determinants of neonatal mortality in Kenya. **Methodology:** A cohort study was carried out at Pumwani Maternity hospital, Thika Level 5 hospital and Machakos Level 5 hospital in Kenya with a sample of 343 stable LBW infants (≤2000g). Informed by the concepts of the Mosley and Chen (1984) analytical framework, several socioeconomic and proximate characteristics were included in the study. Cross tabulations and multiple logistic regression analyses were done to determine the relationships between the determinants and neonatal mortality. **Results:** The mean birth weight was 1492.6 g (SD=275.3) and mean gestational age was 30.3 weeks. Most infants (59.8%, N=343) were female. Incidence of neonatal mortality was 8.5% (n=340). Household income, birth complications, birth weight, gestational age and multiple births were significant determinants of neonatal mortality among the LBW infants weighing ≤2000 grams. **Conclusion and recommendations:** The findings affirm the Mosley and Chen (1984) analytical framework on determinants of neonatal survival. The study provides useful information on determinants of neonatal mortality that is relevant to the Kenyan context and applicable to other low income countries.

Keywords: neonatal survival; neonatal mortality; socioeconomic determinants; proximate determinants; low-birth-weight infants

1. INTRODUCTION

The neonatal period is only the first 28 days of life and yet is the most vulnerable time for a child's survival [1,2,3,4]. Goal 3 of the United Nations Sustainable Development Goals call for an end to preventable deaths of newborns and children by 2030. All countries should aim at reducing neonatal mortality to below 12 per 1,000 live births [5]. Neonatal mortality has been declining globally, falling from 33 deaths per 1,000 live births in 1990 to 21 deaths per 1,000 live births in 2012. However, this represents a slow decline of 37 percent compared to the 47 percent in the under-five mortality rate. Pre-term birth has been shown as the largest direct cause of neonatal mortality [6]. Low-birth-weight (less than 2500 g) has a causal relationship with neonatal mortality. Globally, LBW contributes to 60% - 80% of all neonatal deaths [3,4,7,8,9].

In Kenya, all childhood mortality rates have declined between 2003 and 2014. Neonatal mortality however has shown the slowest decline rate of only 33 percent. The neonatal mortality was 22 deaths per 1,000 live births between 2009 and 2014 [10,11]. This was 1.4 times higher than the post neonatal rate. The neonatal mortality rate has distribution disparities with neonatal mortality being 24 percent higher in urban areas than in rural areas. Nairobi, the capital city of Kenya, has the highest neonatal mortality (39 deaths per 1,000 live births). Data from Kenya show that wealthier families experience highest neonatal mortality rates compared to poorer families [10,11].

Mosley and Chen (1984) [12] developed an analytical framework for analyzing determinants of child survival in developing countries. According to the model, impact on mortality is influenced by socioeconomic determinants (independent variables) that operate through a certain set of proximate determinants (intermediate variables). Socioeconomic determinants include variables that relate to the productivity of mothers and fathers. Education level of parents influences their occupation and buying power of the household. Income influences neonatal survival through food choices, water (quantity and quality), housing, clothing, hygiene and sickness care among others [13,14]. Higher education levels are associated with better neonatal outcomes [15] High education, especially maternal, improves the status of women and access to information and health services. Mother's time is necessary for a healthy baby as she requires time for prenatal visits and breastfeeding among others. Traditions, norms and attitudes include factors that affect the economic and health related practices. These may include factors like power relationships within the household, value of children and belief about disease causation among others [12,16,17,18].

The proximate determinants that directly influence the risk of neonatal mortality have been identified as maternal factors; environmental contamination; nutrient deficiency; injury; and personal illness control (which include health interventions). Factors that affect maternal health have impact on neonatal survival. These factors may include maternal age, parity and birth interval. Synergism between these factors may also occur and this differentially affect child survival especially when two or more such unfavorable factors occur together [12]. Household crowding, source of water supply, food handling practices, incidence of diarrhea and/or presence of latrines or toilettes are physical indices associated with environmental contamination. The contamination is directly associated with neonatal morbidity. Nutrient deficiency influence child survival based on the nutrients available to the neonate and the mother [12,13]. Nutrient deficiency during lactation can affect the quality of breast milk. On the other hand, injuries reflect environmental risks that differ in socioeconomic and environmental contexts. Incidence of injuries whether intentional or accidental affect neonatal survival [12,13,19,20].

It is clear that neonatal mortality rates are high in Kenya and that the causes of these are multifactorial. Understanding the specific socioeconomic and proximate determinants of neonatal survival in Kenya can help develop and implement effective interventions that can reduce the neonatal mortality rate, especially among LBW infants which contributes to the majority of neonatal deaths.

2. METHODS AND MATERIAL

2.1 Study Design and Setting

This was a cohort study carried out at Pumwani Maternity hospital, Thika Level 5 hospital and Machakos Level 5 hospital. The sites were selected as part of a larger study on the effectiveness of early intermittent Kangaroo Mother Care; A quasi-experimental study. It is assumed that the facilities share similarities in patient population characteristics and also the health system. Pumwani hospital, located in Nairobi, is one of the largest public maternity referral hospitals in Kenya with 350 beds and 150 cots [21]. Thika Level 5 hospital is one of the largest public hospitals in Kiambu County with 265 beds and 24 cots while Machakos Level 5 hospital is the biggest public health facility in Machakos County with 375 beds and 57 cots [22]. The study population was all stable LBW infants weighing ≤2000 grams irrespective of their gestational age who were admitted at the three hospitals during the study period.

The sample size was 343 drawn from the three facilities by consecutively enrolling eligible LBW infants into the study. The inclusion criteria for the study was infants weighing ≤2000 grams irrespective of their gestational age, infants less than 72 hours of life, stable infants (not on oxygen or phototherapy, on full feeds and retaining, Oxygen saturation of >95%, Heart rate of >100 beats per minute, capillary refill < 3 seconds) and willingness to give written consent. Infants with major congenital malformations or severe perinatal complications and cases where the caregiver was unwilling to give written consent were excluded from the study. The follow up period was the neonatal period (28 days).

2.2 Data Collection and Procedures

Data was collected between June 2016 to June 2017 using structured tools which were guided by the concepts of the Mosley and Chen (1984) analytical framework [12] and from literature review (Fig. 1).

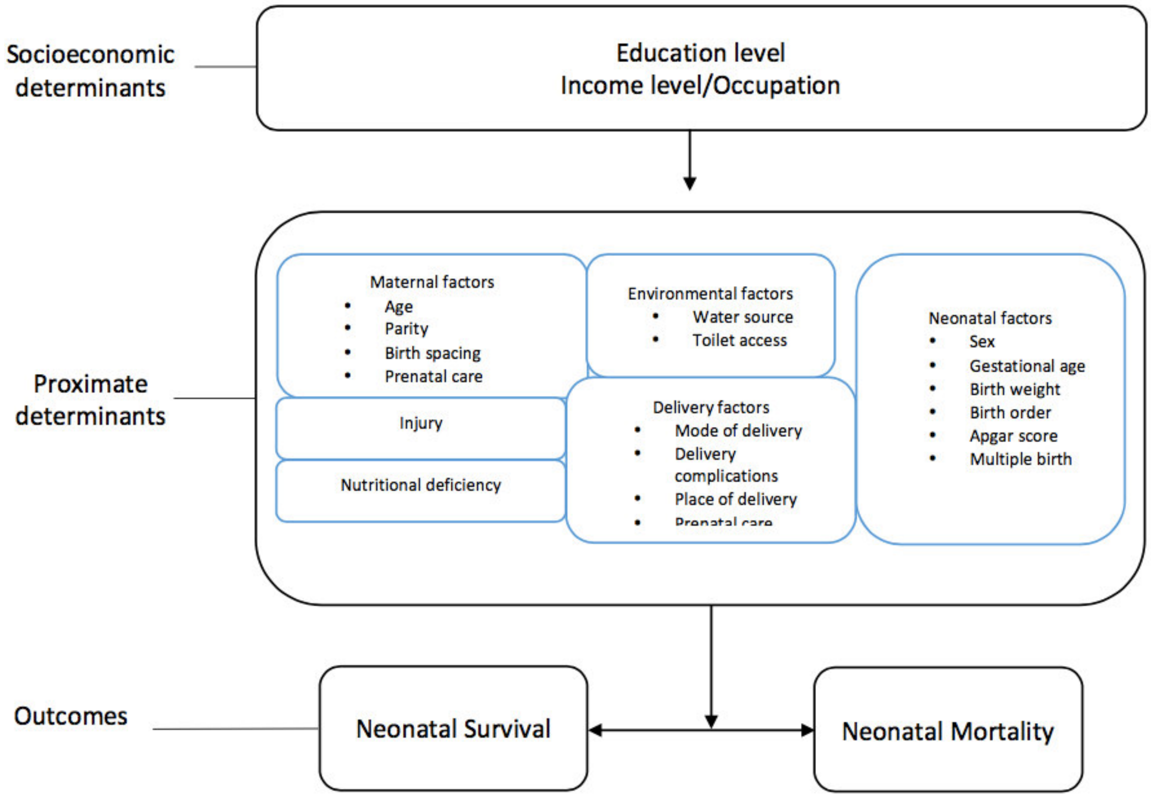

Figure 1: Adopted Mosley and Chen Analytical Framework (1984) [12]

The data collection tools were pre-tested before onset of the study. An entry questionnaire was administered within 72 hours post-delivery through face to face interviews in the neonatal unit, at a time that was convenient to the mother. An exit questionnaire was administered at the last follow up (at 28 days of age) asking details about incidence of injury, nutritional factors and environmental factors. A data abstraction tool was used to obtain information from the patient files.

2.3 Data Management and Analysis

Microsoft Excel was used for data entry and storage. Data analysis was done using Stata Statistical Software [23]. An alpha of 0.05 was used for statistical significance. Initially, basic descriptive statistics were used to describe the respondents' socioeconomic characteristics. Cross tabulations were done to determine the relationships between independent and dependent variables. Multiple logistic regression analysis was conducted to determine the predictors of neonatal morbidity and mortality. The variables included in the regression model were based on their clinical significance. A backward stepwise method was used in coming up with a minimum set of determinants that resulted in the optimal predictive model of the final outcomes.

2.4 Ethical Considerations

Ethical clearance for the study was given by the Kenyatta National Hospital Ethics Review Committee after reviewing the study protocol. Institutional permission was sought from the respective County authorities and Medical Superintendents of the study hospitals. Permit to conduct the study was given by National Commission for Science, Technology and Innovation (NACOSTI). An informed consent was obtained and confidentiality was ensured by coding the questionnaires.

3. RESULTS

3.1 Socioeconomic characteristics

A total of 343 LBW infants were recruited in the study between July 2016 to June 2017. The mean age of the mothers was 25.4 (SD=5.3), range 15-45 years. Majority of the mothers, 79.9% (N=343) were married/cohabiting, with half of them (50.2%, N=343) having secondary education. More than half of the spouses (59.4%, n=283) had secondary education. A third of the mothers had household income of below 6,000 Kenya shillings per month (about 60 USD), with majority 78.1% (N=343) renting the house they were living in. Two in every ten (22.2%, n=338) of the mothers were living in a temporary house with a similar number (23.9%, N=343) having no access to a toilet. A third of the mothers used kerosene as the main fuel for cooking. A small fraction of mothers, 5.5% (N=343) used river/pond as the source of water for drinking. A few of the mothers, 10.9% (n=339) had an incidence of diarrhea in the last three months before delivery.

3.2 Proximate characteristics

The average birth weight was 1492.6 grams (SD=275.3), range 700-2000 grams. The average gestational age among the mothers was 30.3 weeks (3.8), 20-40 weeks. More than half (59.8%, n=343) of the infants were female, and majority (78.4%, N=343) were born in the study hospital. Most of the infants (83.3%, n=342) were born through spontaneous vaginal delivery and only a third (29%, n=341) were multiple births. Delivery complications were recorded in 26.6% (n=342) of the births. About two thirds (63.9%, n=144) of the infants had a birth interval of more than 36 months. A few of the mothers (4.4%, n=342) reported taking only one meal on average during their most recent pregnancy. Most (93.2%, n=339) of the mothers attended antenatal clinic while pregnant. About half (51.4%, n=329) of the mothers reported having no pregnancy loss and having 1 or more live births prior to their most recent pregnancy. Nearly a third (30%, N=343) of the mothers had not used micronutrient supplementation during their most recent pregnancy. HIV prevalence was 8.5% (n=329) among the mothers while prevalence of non communicable diseases was 13.1% (N=343) among the mothers. Few (2.9%, N=343) mothers reported use of alcohol and 0.9% (n=342) reported cigarette smoking during pregnancy. Cigarette smoking among partners were reported in 7.7% (n=274) of the mothers. Majority (81.4%, n=301) of the infants had an Apgar score at 1 minute of more than 5.

3.3 Incidence of neonatal mortality

A total of 29 (8.5%, n=340) LBW infants died during the neonatal period in the three hospitals.

3.4 Association between selected socioeconomic characteristics and neonatal mortality

Maternal level of education, access to toilet and incidence of diarrhea in the last 3 months before delivery was significantly associated with neonatal mortality (p<0.05) as shown in Table 1 below. All the other socioeconomic characteristics were not significantly associated with neonatal death (p>0.05).

Table 1. Association between selected socioeconomic characteristics and neonatal mortality

Variable		Mortality (Yes)	P Value
		n (%)	
Marital status	Married	26 (9.6%)	0.174
	Single	3 (4.4%)	
Maternal level of education	Primary & below	17 (14.5%)	0.011*
	Secondary	11 (6.5%)	(Fishers Exact)
	Tertiary	1 (1.9%)	
Spouses level of education	Primary & below	4 (8.2%)	0.861
	Secondary	15 (9%)	
	Tertiary	7 (10.9%)	
Income per month	<6000	14 (12.8%)	0.213
	6000 to 15000	9 (8.3%)	
	>15000	6 (6%)	
Type of house ownership	Own	7 (9.3%)	0.778
	Rented	22 (8.3%)	
Access to toilet	No	15 (18.8%)	0.000*
	Yes	14 (5.4%)	
Source of fuel for cooking	Electricity/Gas	13 (8.1%)	0.603
	Charcoal	5 (6.6%)	
	Kerosene	11 (10.7%)	
Source of drinking water	piped	21 (7.5%)	0.196
	river/pond	3 (15.8%)	
	well/borehole	5 (12.5%)	
Incidence of diarrhea in last 3 months	No	22 (7.3%)	0.018*
	Yes	7 (18.9%)	

*. The Chi-square statistic (Fishers Exact) is significant at the 0.05 level

3.4 Association between selected proximate characteristics and neonatal mortality

The proximate characteristics significantly associated with neonatal mortality were multiple births, delivery complications and average number of meals per day during pregnancy (p<0.05). Table 2 shows the association of proximate characteristics and neonatal mortality including those that were not statistically significant (p>0.05).

Table 2. Association between selected socioeconomic characteristics and neonatal mortality

Variable		Mortality (Yes) n (%)	P Value
Infant Sex	Female	18 (8.9%)	0.761
	Male	11 (8%)	
Place of delivery	This hospital	22 (8.2%)	0.774
	Another hospital	4 (8.7%)	
	Home	3 (11.5%)	
Mode of delivery	CS	3 (5.3%)	0.441
	Normal	26 (9.2%)	
Multiple births	No	12 (5%)	0.000*
	Yes	17 (17.2%)	
Delivery complications	No	15 (6.1%)	0.006*
	Yes	14 (15.4%)	
Birth interval	<18 months	4 (16.7%)	0.328
	18-36 months	2 (7.7%)	
	>36 months	6 (6.5%)	
Average number of meals per day when pregnant	One	6 (40%)	0.002*
	Two	3 (7.3%)	
	Three	12 (6.2%)	
	More than three	8 (9%)	
ANC attendance	No	2 (9.1%)	0.937
	Yes	27 (8.6%)	
Pregnancy history	Never pregnant	9 (8.2%)	0.918
	No pregnancy loss with 1 or more live births	14 (8.3%)	
	1 or more pregnancy loss with 1 or more live births	4 (10.5%)	
	1 or more pregnancy loss with no live birth	0 (0%)	
Use of micronutrient supplementation	No	7 (7%)	0.515
	Yes	22 (9.2%)	
HIV status	Negative	28 (9.4%)	0.49
	Positive	1 (3.7%)	
Chronic conditions (NCDs)	No	23 (7.8%)	0.215
	Yes	6 (13.3%)	
Apgar score at 1 minute	Apgar score 1-5	6 (10.7%)	0.412
	Apgar Score 6-10	18 (7.4%)	

*. The Chi-square statistic (Fishers Exact) is significant at the 0.05 level

Birth weight and gestational age were significantly associated with incidence of neonatal mortality. A unit increase in birth weight (1 gram) was associated with a 0.3% reduction in likelihood of neonatal mortality [OR=0.997, 95% CI, 0.996-0.999, p=0.0002]. Similarly, a unit increase in gestational age (1 week) was associated with a 14% reduction in likelihood of neonatal mortality [OR=0.86, 95% CI, 0.77-0.96, p=0.009]. The age of the mother and birth order were not statistically associated with the incidence of neonatal mortality [p>0.05].

Table 3. Association between birth weight, gestational age, birth order and age of the mother with neonatal mortality

Neonatal Mortality	Unadjusted odds ratio	95% CI	P value
Birth weight (grams)	0.997	0.996-0.999	0.002
Gestational age (weeks)	0.86	0.77-0.96	0.009
Birth order	1.3	0.8-2.1	0.328
Age mother (Years)	0.96	0.9-1.0	0.321

3.5 Multiple analysis of association of selected determinants with neonatal mortality

A multiple logistic regression analysis was performed to ascertain the effects of socioeconomic characteristics and proximate characteristics on the likelihood of neonatal mortality. Twelve successive iterations were performed using forward and backward stepwise method retaining eight determinants in the final model. The logistic regression model as a whole was statistically significant [likelihood ratio χ2 (9) =48.8, p<0.000].

Household income per month was significantly associated with neonatal mortality. Infants born in families with a household income of 6,000-15000 (60 – 150 USD) were 60% less likely to die during neonatal period compared to those born in families with a household income of less than 6000 (60 USD) per month [OR=0.4, 95% CI, 0.1-1.1, p=0.004]. LBW infants born in families with household income of more than 15000 (>150 USD) per month were 84% less likely to die during neonatal period than LBW infants born in families with a household income of less than 6000 (60 USD) per month [OR=0.16, 95% CI, 0.04-0.56, p=0.004].

Birth complications were significantly associated with incidence of neonatal mortality. LBW infants of mothers who had birth complications were 4.1 times more likely to die [OR=4.1, 95% CI, 1.6 -10.8, p=0.004] compared to those of mothers who did not have birth complications.

Birth weight (grams)and gestational age (weeks) were significantly associated with neonatal mortality. A unit increase in birth weight (1 gram) was associated with a 0.3% reduction in likelihood of neonatal mortality [OR=0.997, 95% CI, 0.995-0.999, p=0.032]. Similarly, a unit increase in gestational age (1 week) was associated with a 21% reduction in likelihood of neonatal mortality [OR=0.79, 95% CI, 0.68-0.92, p=0.002].

Multiple birth was significantly associated with neonatal mortality. Infants born as multiple births were 6.6 times more likely to die than singleton infants [OR=6.6, 95% CI, 2.5-17.4, p<0.001]. Infant sex and mode of delivery were not statistically associated with a reduction of neonatal mortality (p>0.05) as shown in Table 4.

Table 4. Multiple analysis of association of selected determinants with neonatal mortality

Neonatal mortality	Adjusted Odds Ratio	95% CI	P value
Household income (KES)	Ref cat <6000 KES (60 USD)		
6000 to 15000	0.400223	0.1-1.1	0.078
>15000	0.1599596	0.04-0.56	0.004
Birth complication	4.109571	1.6-10.8	0.004
NCDs	2.802114	0.8-9.2	0.091
Birth weight	0.9978971	0.996-0.999	0.032
Gestational age	0.7920633	0.68-0.91	0.002
Infant sex	1.561453	0.6-4.0	0.357
Mode of delivery (Normal)	2.880042	0.6-12.9	0.168
Multiple birth	6.62262	2.5-17.4	0.000

4. DISCUSSION

The neonatal mortality in this study was 8.5% (n=340) among the LBW infants weighing ≤2000 grams. This was considerably lower than neonatal mortality rates reported in other studies. Simiyu (2004) reported a neonatal mortality rate of 57.4% (n=533) among LBW infants at Kenyatta National Hospital, Kenya [24]. The difference can be explained by the difference in eligibility criteria where our study enrolled only stable LBW infants. A KMC trial in 2005 reported an overall 30.4% (n=125) neonatal mortality which was much higher than in this study [25]. It is notable that the clinical trial also included unstable LBW infants, which may explain the higher neonatal mortality rate. Nagai, et al., (2010) reported a neonatal mortality rate of 4.1% (n=73) which was much lower than that reported in our study. This trial was putting both study groups on either early or late KMC and this may have had an overall effect on the overall low neonatal mortality rate [26].

Our study found that household income was the only the socioeconomic determinant that was significantly associated with neonatal mortality. Mosley & Chen (1984) analytical framework have identified several socioeconomic determinants that work through proximate determinants to influence neonatal mortality [12]. Most of these socioeconomic factors are associated with household income and would agree with findings of another study in Ghana that found dwelling in low socioeconomic neighbourhoods being associated with high neonatal mortality [27]. Olayinka et al. (2012) identified maternal level of education to have a significant relationship with neonatal survival [28]. Increasing household income increases the buying power and improved quality of living. This would result in better access to quality water and reduced incidence of diarrhoea. The overall effect is improvement of neonatal survival.

We identified some proximate determinants that significantly affected neonatal mortality. These included multiple births and delivery complications. Mosley & Chen (1984) identify the same as having adverse effects on neonatal survival [12]. An observational study in Ghana also identified multi-gestation as a significant contributor of neonatal mortality [27]. Multiple births are typically associated with LBW and this may contribute to poor neonatal survival. The study in Ghana reported inadequate birth spacing, ANC utilization, grand parity and place of delivery as significant factors of neonatal survival [27]. Olayinka et al. (2012) in their study found that the place of delivery had a significant relationship with neonatal mortality [28]. These findings were contrary to our cohort study findings that showed a non significant relationship between these determinants and neonatal mortality.

Several other proximate determinants in our study including maternal and/or paternal level of education, infant sex, toilet access, mode of delivery, use of micronutrients, HIV status and Apgar score at one minute did not influence neonatal survival as envision in the Mosley and Chen (1984) analytical framework [12]. Janaswamy et al. (2016) did not also find a significant relationship between infant sex and mode of delivery with neonatal mortality [29]. In our study, this may be due to the small proportion of neonatal deaths that may partly be attributed to the eligibility criteria of stable infants.

Birth weight and gestational age had a significant relationship with neonatal mortality, which was in agreement with the Mosley & Chen (1984) analytical framework [12]. Many other studies agree that lower birth weight infants have a lower chance of surviving during the neonatal period [27,29] and that LBW is responsible for 60-80% of neonatal deaths in many developing countries [7,30].

5. CONCLUSIONS

The study confirmed that there are certain socioeconomic and proximate determinants that affect neonatal mortality as proposed by the Mosley and Chen (1984) analytical framework. This study identified household income, birth complications, birth weight, gestational age, and multiple births as significant predictors of neonatal mortality. The study provides useful information on determinants of neonatal mortality that is relevant to the Kenyan context and applicable to other low income countries. This knowledge is useful in designing interventions and policies that can reduce neonatal mortality.

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