Factors influencing neonatal mortality: an analysis using the Swaziland Demographic Health Survey 2007

Eugene Zwane, Sdumo Masango

Department of Statistics and Demography, Faculty of Social Sciences, University of Swaziland

Abstract

This study examines the effects of socioeconomic and maternal variables on the probability of neonatal deaths. An understanding of the factors related to neonatal mortality is important in guiding the development of focused and evidence-based health interventions to prevent neonatal deaths. The data source for the analysis was the 2006-07 Swaziland Demographic and Health Survey from which survival information on 1727 infants born within the 3 years preceding the survey. Design based logistic regression incorporating survey weights was performed to analyze the associated factors. Compared to infants born at home, the odds of dying were significantly lower for infants born in a private facility (OR=0.37, 95% CI: 0.15-0.90). Neonates born in public facilities and those born at home had similar odds of dying. For newborns, whose birth size according to the mother was smaller than average, the odds of dying were more than 4 times the odds for large-sized babies (OR=4.72, 95% CI: 1.66-13.36).

Introduction

According to the Convention on the Rights of the Child,[1] newborns have a basic right to enjoy the highest attainable standard of health. Yet a recent review of child mortality has revealed that the proportion of under-five child deaths occurring in the first month of life has been increasing.[2] Of 130 million babies born annually, more than 4 million die in the neonatal period, and 99 per cent of these deaths occur in developing countries.[3,4] During the last 30 years, the reduction in neonatal mortality rates has been slower, compared to both under-five and child mortality rates after the first month of life.[5] Despite accounting for almost 40 per cent of all under-five child deaths and more than half of infant deaths, neonatal mortality is not a target of the Millennium Development Goals (MDGs). However if the MDG target of a two-thirds reduction in child mortality by 2015 is to be achieved then neonatal mortality must be addressed.

Swaziland is one of the smallest landlocked countries in the world, and according to the 2007 population census, the population of Swaziland reached 1.1 million, of which 77 per cent live in urban areas.[6] In 2007 Swaziland conducted its first national survey as part of the Demographic and Health Surveys (DHS). The 2006-07 Swaziland Demographic Health Survey (SDHS) is a nationally representative sample of 4843 households, 4987 women aged 15-49 years and 4156 men aged 15-54 years.[6] The survey of persons aged 12-14 and aged 50 and over was carried out in every other household selected in the SDHS yielding 459 girls and 411 boys aged 12-14, and 661 women and 456 men aged 50 and over. The survey aimed to gather information about child mortality, and maternal and child health, as well as family planning and other reproductive health issues.

The neonatal mortality rate in Swaziland in 2005 was reported to be 40 per 1000 live births, which according to the World Health Organization estimates was similar to the average for other Southern African countries.[7] However over the preceding 15 years, neonatal mortality had undergone considerable improvement with a reduction in the rate of approximately 40 per cent. In the SDHS 2006-07 the neonatal mortality rate was reported to be 22 per 1000 live births.

Poor social conditions are known to affect maternal health, which again has impact on neonatal mortality.[3,8] Social developments such as improved maternal education, household income and environmental conditions should, therefore, have effects on child mortality in developing countries.[9,10] Still, the impact of improved maternal education and other sociodemographic conditions on pregnancy outcome may depend on the cultural setting. Few studies have assessed how sociodemographic patterns are related to neonatal mortality in Africa.[11-14]

Previous reviews of the causes of neonatal deaths have demonstrated that up to 70 per cent of neonatal mortality could be prevented using evidence-based interventions. To adopt a focused, evidence-based approach to reduce neonatal mortality in Swaziland, a clear understanding of the associated factors is necessary. Using the 2006-07 SDHS data, this study examined the determinants of neonatal mortality for all infants of the sampled women who were born between 2004 and 2007.

Correspondence: Eugene N. Zwane, University of Swaziland, Private Bag 4, Kwaluseni, Swaziland. Tel: +268.25170062. E-mail: ezwane@uniswa.sz

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Materials and Methods

Sources of data

The data examined was the 2006-07 SDHS. The 2006-07 SDHS samples for each administrative district were stratified by urban and rural areas. Within each stratum, the primary sampling unit was the Enumeration Area (EA) defined during the 2005 population census, which were selected using multistage stratified random sampling. EA's were selected using systematic random sampling, followed by a random selection of ten households in each EA.

The 2006-07 SDHS used three questionnaires, the Household Questionnaire, the Women's Questionnaire for ever-married women aged 15-49 years, and the Men's Questionnaire for all currently married men 15-54 years old. Both the Household and Women's Questionnaires were based on the standard DHS questionnaires were modified to capture issues concerning family planning and health specific to Swaziland.[6] The Household Questionnaire listed all the usual household members and recorded information about their age, sex, education and relationship to head of household as well as shared household level characteristics such as an inventory of household assets. The information recorded on the Women's Questionnaire included the women's demographic characteristics, their full birth history, their history of antenatal care

for the most recent birth within a five-year period preceding the survey, delivery and postnatal care for all births, as well as the survival of their live-born infants. The information recorded on the Men's Questionnaire included their demographic characteristics and their reproductive history.

Study variables

The primary outcome was neonatal death, which was the death of a live born infant in the first month of life. In the descriptive analyses, the neonatal mortality rate, defined as the number of neonatal deaths per 1000 live births, was used. In these analyses, the outcome was neonatal deaths recoded as a binary variable. The explanatory variables included socioeconomic and proximate determinants, covering maternal, neonatal, and delivery factors.

Table 1 shows a list of all the variables used in this study along with their definitions and categorizations. The individual and household level socioeconomic variables included in the study were maternal marital status, maternal and paternal education, parental occupation, and household wealth index. The wealth index was calculated using an inventory of households' assets which were weighted using principal components analysis method.[15] The household assets used in constructing the index included; the ownership of durable goods, such as television, radio, and refrigerator; household facilities, such as electricity, and type of toilet; indicators of the condition of housing, such as the primary material used for the floor and walls; and ownership of transportation devices, such as bicycle, motorcycle and car/truck. The household wealth index was the sum of the weighted scores for each item, and was used in the analyses as a discrete variable. In Swaziland, household contamination is still a big problem. Piped water is provided to a minority of households. Only 39 percent of households have water piped into the dwelling, yard or plot, while 17 percent of households use a public tap or standpipe. Sanitation measures are still not adequate in Swaziland. Improvements in hygienic sanitation facilities lower mortality through the mechanism of less exposure of children to contamination making them less susceptible to disease and eventually death. Only 50 percent of households in Swaziland have access to improved toilet facilities that are not shared with other households. This evidence confirms the importance of sanitation in the study of determinants of neonatal morbidity and mortality. Although the wealth index includes piped water and type of toilet in its computation due to the concerns just presented these variables are also included as potential socioeconomic determinants in this analysis.

Proximate determinants at the individual level were also identified through which socioeconomic variables could possibly have had an impact on neonatal mortality. These variables were maternal age at child birth to represent maternal factors; the infant's sex, maternal subjective assessment of the infant's size, and a combined variable of infant's birth rank and birth interval which represented the neonatal factors; maternal desire for pregnancy as a pre-delivery factor; delivery assistance, and mode of delivery, for delivery factors; and place of delivery. Maternal desire for pregnancy was included in the pre-delivery factor since it might influence maternal health care and health seeking behavior during pregnancy, such as the utilization of antenatal care services.

Statistical analysis

Using contingency table analyses and logistic regression the association between all possible factors and neonatal mortality was assessed. First, frequency tabulations were conducted to describe the data used in this study, followed univariate logistic regression analyses to examine the impact of all potential predictors on neonatal mortality without adjusting for other covariates. All of the potential predictors were also entered into the baseline model to examine their effects simultaneously. As part of the analysis, possible associated factors were examined for evidence of collinearity, which was reflected by either the changes in the direction of effect between the univariate and multivariate analysis, or implausible standard errors for a particular variable. Once observed, the particular factor was examined against each possible factor to

Table 1. Operational definition and categorization of the variables used in the analysis.

Socioeconomic determinants	Definitions and categorization
Cluster type	Type of the cluster (1=urban; 2=rural)
District	Administrative district (1=Hhohho; 2=Manzini; 3=Shiselweni; 4=Lubombo)
Maternal marital status	Marital status of the mother (1=never married; 2=currently married; 3=formerly married)
Maternal education	Education (1=no education; 2=primary; 3=secondary or higher)
Paternal education	Education (1=no education; 2=primary; 3=secondary or higher)
Maternal occupation	Occupation (1=not working; 2=working)
Paternal occupation	Occupation (1=not working; 2=working)
Piped drinking water	Piped drinking water (1=no; 2=yes)
Flush toilet	Flush toilet (1=no; 2=yes)
Household wealth index	Composite index of household amenities (1=poor; 2=middle; 3=rich)
Proximate determinants	
Maternal age at first birth	Age at first birth (1=less than 15; 2=15 to 24; 3=25 and above)
Maternal age at childbirth	Age at childbirth (1=less than 20; 2=20 to 34; 3=35 and above)
Sex	Sex of the neonate (1=female; 2=male)
Type of birth	Sex of the neonate (1=singleton; 2=multiple)
Birth size	Subjective assessment of the respondent on the birth size (1=average; 2=smaller than average; 3=larger than average)
Birth rank and birth interval	Birth rank and birth interval of neonate (1=first birth; 2=2nd or 3rd birth rank, birth interval ≤2 years; 3=2nd or 3rd birth rank, birth interval 2 years; 4=≥4th birth rank, birth interval ≤2 years; 5=≥4th birth rank, birth interval >2 years)
Delivery assistance	Birth attendance during delivery (1=health professional; 2=traditional birth attendant/other)
Desire for pregnancy	Intention to become pregnant (1=wanted then; 2=wanted later; 3=wanted no more)
Mode of delivery	Mode of delivery (1=non-Caesarean section; 2=Caesarean section)
Place of delivery	Place of delivery (1=home; 2=public health facility; 3=private health facility)

Table 2. Percentage distribution of children by covariates used in the analysis of neonatal mortality.

Variable Total	Number of women 1560	Births (%) 1727	Deaths (Weighted NMR) 47(26.2)
Socioeconomic determinants			
Type of place of residence (Valid=1727)			
Urban	407	446 (25.8)	12 (23.2)
Rural	1153	1281 (74.2)	35 (27)
District (Valid=1727)			
Hhohho	381	424 (24.6)	15 (38)
Manzini	436	486 (28.1)	10 (18.5)
Shiselweni	360	393 (22.8)	12 (27.4)
Lubombo	383	424 (24.6)	10 (21.5)
Marital status (Valid=1727)			
Never married	619	674 (39)	20 (29.1)
Married/(not) living together	898	1009 (58.4)	26 (23.7)
Widowed/divorced	43	44 (2.5)	1 (36.9)
Maternal education (Valid=1727)			
Primary or lower	681	776 (44.9)	18 (22.7)
Secondary or higher	879	951 (55.1)	29 (28.9)
Paternal education (Valid=1032)			
Primary or lower	435	498 (48.3)	8 (14.7)
Secondary or higher	487	534 (51.7)	19 (33.9)
Mother's occupation (Valid=1725)			
Not working	892	986 (57.2)	26 (27.3)
Working	666	739 (42.8)	21 (24.7)
Paternal occupation (Valid=1036)			
Not working	137	163 (15.7)	4 (23.9)
Working	788	873 (84.3)	23 (24.8)
Piped drinking water (Valid=1727)			
No	829	919 (53.2)	23 (25.1)
Yes	731	808 (46.8)	24 (27.3)
Flush toilet (Valid=1726)			
No	1333	1487 (86.2)	40 (26.2)
Yes	226	239 (13.8)	7 (26.3)
Wealth index (Valid=1727)			
Poor	644	737 (42.7)	19 (24.4)
Middle	310	336 (19.5)	11 (30.6)
Rich	606	654 (37.9)	17 (25.8)
Proximate determinants			
Age at first birth (Valid=1727)			
<18	573	639 (37)	18 (28.1)
18-24	902	995 (57.6)	24 (21.9)
25+	85	93 (5.4)	5 (62.2)
Age at birth (Valid=1727)			
<20	376	413 (23.9)	13 (26.3)
20-34	1012	1128 (65.3)	32 (27.7)
35+	172	186 (10.8)	2 (16.2)
Sex of child (Valid=1727)			
Male	801	875 (50.7)	20 (21)
Female	759	852 (49.3)	27 (31.5)
Type of birth (Valid=1727)			
Single	1534	1675 (97)	43 (24.7)
Twin	26	52 (3)	4 (72)
Birth size (Valid=1668)			
Large	410	462 (27.7)	6 (9.5)
Average	891	969 (58.1)	25 (25.8)
Small	209	237 (14.2)	11 (41.3)
Birth rank and birth interval (Valid=1727)			
1st birth rank	539	571 (33.1)	19 (29.2)
2nd or 3rd rank, birth interval ≤2years	81	111 (6.4)	5 (52.1)
2nd or 3rd rank, birth interval >2years	499	532 (30.8)	12 (16.9)
4th rank and above, birth interval ≤2years	70	103 (6)	1 (9.2)
4th rank and above, birth interval >2years	371	410 (23.7)	10 (31.3)

NMR, neonatal mortality rate.

To be continued on next page.

identify the variable with which it was highly correlated. Logistic regression was then performed to identify the significant independent determinants of neonatal mortality. All variables that were significantly associated with neonatal mortality at the 10 percent level of significance from the univariate logistic regression models were included in the multivariate logistic regression model.

SDHS data sets have a hierarchical structure, with women or men within households, which are within EA's. This data structure violates an underlying assumption for usual logistic regression models of independence of the observations. Instead the observations in these datasets are clustered within each EA. We adopted a design based modeling approach instead of the multilevel modeling methods frequently used in literature. Both these approaches adjust for this clustering of observations within EA and provided correct estimates of the standard errors.

Odds ratios and 95 per cent confidence intervals were determined, and all estimates were weighted by the sampling probabilities. Two variables, maternal age at child birth and household wealth index were chosen a priori and retained in the final model, regardless of their level of significance, because they have previously been shown to be associated with the increased risk of neonatal mortality.[16,17]

All of the statistical analyses were performed using R,[18] and the logistic regression was conducted using the survey library.[19,20]

Results

To identify the associated factors for neonatal mortality, 1727 live-born infants within the three years preceding the survey were included as the study population (only infants who could have lived through the first month are included in this analysis). This analysis found that between 2004 and 2007, 2.6 per cent of infant deaths occurred during the neonatal period.

The characteristics of the study variables are presented in Table 2. Around 57 per cent of the infants were born to mothers who did not have a job outside the home. Only less than 16 per cent of infants were born to fathers who

Table 2. Continued from previous page.

Variable Total	Number of women 1560	Births (%) 1727	Deaths (Weighted NMR) 47(26.2)
Age at first birth (Valid=1727)			
<18	573	639 (37)	18 (28.1)
18-24	902	995 (57.6)	24 (21.9)
25+	85	93 (5.4)	5 (62.2)
Age at birth (Valid=1727)			
<20	376	413 (23.9)	13 (26.3)
20-34	1012	1128 (65.3)	32 (27.7)
35+	172	186 (10.8)	2 (16.2)
Sex of child (Valid=1727)			
Male	801	875 (50.7)	20 (21)
Female	759	852 (49.3)	27 (31.5)
Type of birth (Valid=1727)			
Single	1534	1675 (97)	43 (24.7)
Twin	26	52 (3)	4 (72)
Birth size (Valid=1668)			
Large	410	462 (27.7)	6 (9.5)
Average	891	969 (58.1)	25 (25.8)
Small	209	237 (14.2)	11 (41.3)
Birth rank and birth interval (Valid=1727)			
1st birth rank	539	571 (33.1)	19 (29.2)
2nd or 3rd rank, birth interval ≤2years	81	111 (6.4)	5 (52.1)
2nd or 3rd rank, birth interval >2years	499	532 (30.8)	12 (16.9)
4th rank and above, birth interval ≤2years	70	103 (6)	1 (9.2)
4th rank and above, birth interval >2years	371	410 (23.7)	10 (31.3)
Delivery assistance (Valid=1726)			
Some assistance	1496	1648 (95.5)	46 (26.8)
No assistance	64	78 (4.5)	1 (12.6)
Desire for pregnacy (Valid=1725)			
Then	524	576 (33.4)	16 (22.8)
Later	432	483 (28)	13 (31.1)
No more	604	666 (38.6)	18 (25.6)
Mode of delivery (Valid=1723)			
Non-caesarean	1428	1583 (91.9)	42 (25.2)
Caesarean	128	140 (8.1)	5 (38.2)
Place of delivery (Valid=1726)			
Home	367	422 (24.4)	14 (32)
Public facility	687	757 (43.9)	25 (32.9)
Private facility	506	547 (31.7)	8 (12.2)

NMR, neonatal mortality rate.

were unemployed. Approximately 25 per cent of the deliveries occurred at home. However, this survey revealed that 96 per cent of the deliveries were assisted.

Table 3 summarizes the crude and adjusted odds ratios of the possible factors associated with neonatal mortality. This study found a no variation in the odds of neonatal mortality by administrative district or by type of place of residence.

For newborns, whose birth size according to the mother was smaller than average, the odds of dying were more than 4 times the odds for large-sized babies. The odds of dying for average-sized babies were more than 2 times the odds for large-sized babies. Another important predictor for neonatal mortality was the place of delivery. Compared to infants born and home, the odds of dying were significantly lower for infants born in a private facility (OR=0.37, 95% CI:0.15-0.90, Table 3). The odds of dying for children born in a private facility are further reduced in the multivariate model (OR=0.21, 95% CI:0.07-0.62, Table 3). Infants delivered in public facilities have equivalent survival prospects as infants delivered at home.

Twins have insignificant but higher odds of dying in both the univariate and multivariate models. The study found some relationship between paternal education and infant death. Infants born to fathers with at least secondary education have higher odds of dying compared to infants born to fathers with at most primary education. This observation was puzzling, but it could not be explored in the multivariate model due to the high number of missing educational status for the dads (Table 2).

Discussion

Our analyses of the 2006-07 SDHS have revealed that infant size and place of delivery were associated with neonatal mortality.

This study had several strengths. First, the 2006-07 SDHS was a nationally representative survey, using standardized methods that achieved high individual and household response rates. The second was the use of neonatal survival data from a three-year period preceding the survey, which has been shown to reduce recall errors about birth, and death dates by the interviewed mothers. The third was the use of the design-based modeling that took into account all features of the data as well as the variability within the community, household and individual levels to better esti-

Table 3. Factors associated with neonatal mortality: unadjusted and adjusted odds ratio.

Variable	Unadjusted OR (95% CI)	Unadjusted P-value	Adjusted OR (95% CI)	Adjusted P-value
Socioeconomic determinants				
Type of place of residence		0.676		
Urban	1			
Rural	1.168 (0.575:2.371)			
District		0.269		
Hhohho	1			
Manzini	0.477 (0.200:1.137)			
Shiselweni	0.714 (0.305:1.672)			
Lubombo	0.555 (0.226:1.364)			
Marital status		0.718		
Never married	1			
Married/(not) living together	0.808 (0.453:1.441)			
Widowed/divorced	1.278 (0.165:9.909)			
Maternal education		0.419		
Primary or lower	1			
Secondary or higher	1.282 (0.678:2.422)			
Paternal education		0.044		
Primary or lower	1			
Secondary or higher	2.346 (0.929:5.927)			
Mother's occupation		0.735		
Not working	1			
Working	0.901 (0.496:1.638)			
Paternal occupation		0.947		
Not working	1			
Working	1.038 (0.332:3.249)			
Piped drinking water		0.775		
No	1			
Yes	1.090 (0.608:1.954)			
Flush toilet		0.989		
No	1			
Yes	1.007 (0.425:2.384)			
Wealth index		0.837		0.921
Poor	1		1	
Middle	1.266 (0.577:2.775)		1.190 (0.482:2.937)	
Rich	1.061 (0.499:2.257)		1.096 (0.425:2.825)	

To be continued on next page.

mate the level of association of the study factors with the outcome.

However, the study had several limitations that should be noted when interpreting the results. First, only surviving women were interviewed, which may have lead to an underestimate of the neonatal mortality rate, because of the association of neonatal deaths with maternal deaths. This could also have lead to an underestimate of the effect of some of the associated factors, such as delivery complications. Second, there are other possible determinants of neonatal mortality, which were not available in the SDHS dataset, such as environmental and genetic factors, or were only available for the most recent delivery of a mother occurring within the last three years preceding the survey, such as the utilization of antenatal care services. Third, several variables in the study were not infant-specific because they only reflected the most recent conditions or birth, such as maternal and paternal occupation, which represented the employment status within the last twelve months preceding the survey. Furthermore, information provided by respondents, for example the subjective assessment of birth size, could not be validated. Nonetheless, these limitations are unlikely to have substantially influenced the validity of the analyses.

Infant size emerged as one of the strongest predictors of neonatal mortality. This finding is supported by other literatures that have identified low birth weight as a strong predictor of neonatal mortality. A study in Bangladesh reported that approximately 75 per cent of neonatal deaths associated with low birth weight were attributed to preterm birth rather than small for gestational age infants.[21] However, in this study, we were unable to differentiate between preterm and small for gestational age infants.

Place of delivery also plays a significant role in predicting neonatal mortality. Infants delivered in private facilities have lower chances of dying compared to infants delivered at home or in public facilities. The survival prospects at 30 days for infants born at home or in public facilities are the same. These findings indicate that the level of care in public facilities is no different from home-based care but private facilities provide better care to the infants.

Conclusions

The 2006-07 SDHS data examined in this analysis demonstrated that individual, house-

Table 3. Continued from previous page.

Variable	Unadjusted OR (95% CI)	Unadjusted P-value	Adjusted OR (95% CI)	Adjusted P-value
Proximate determinants				
Age at first birth		0.127		0.090
<18	1		1	
18-24	0.773 (0.435:1.373)		0.610 (0.326:1.141)	
25+	2.293 (0.819:6.419)		2.095 (0.563:7.793)	
Age at birth		0.632		0.299
<20	1		1	
20-34	1.054 (0.518:2.145)		1.123 (0.520:2.429)	
35+	0.609 (0.133:2.794)		0.380 (0.045:3.224)	
Sex of child		0.171		
Male	1			
Female	1.516 (0.823:2.791)			
Type of birth		0.078		0.147
Single	1		1	
Twin	3.059 (1.042:8.982)		2.541 (0.768:8.414)	
Birth size		0.021		0.019
Large	1		1	
Average	2.770 (1.028:7.465)		2.873 (1.071:7.706)	
Small	4.498 (1.566:12.920)		4.721 (1.668:3.361)	
Birth rank and birth interval		0.155		
1st birth rank	1			
2nd or 3rd rank, birth interval ≤2years	1.828 (0.573:5.829)			
2nd or 3rd rank, birth interval >2years	0.571 (0.264:1.235)			
4th rank and above, birth interval ≤2years	0.310 (0.043:2.238)			
4th rank and above, birth interval >2years	1.074 (0.441:2.615)			
Delivery assistance		0.398		
Some assistance	1			
No assistance	0.463 (0.062:3.468)			
Desire for pregnancy		0.698		
Then	1			
Later	1.379 (0.592:3.208)			
No more	1.125 (0.510:2.483)			
Mode of delivery		0.390		
Non-Caesarean	1			
Caesarean	1.537 (0.549:4.303)			
Place of delivery		0.031		0.004
Home	1	1		
Public facility	1.026 (0.528:1.994)		0.900 (0.413:1.962)	
Private facility	0.373 (0.154:0.904)		0.213 (0.073:0.623)	

hold and community level variables had a significant impact on neonatal mortality. These findings point to the need for comprehensive prevention strategies to further reduce neonatal mortality in Swaziland.

At the household and individual levels, health promotion strategies to increase awareness of the importance of timely and appropriate postnatal care service utilization and the benefits of birth spacing are needed given their protective effect on neonatal mortality. Interventions to prevent low birth weight would also contribute to further reductions of neonatal mortality in Swaziland.

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