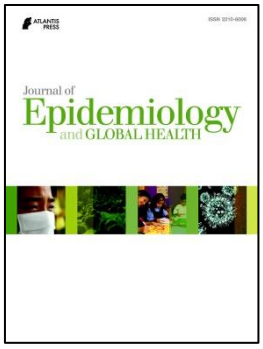

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Neonatal mortality in Nepal: A multilevel analysis of a nationally representative

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Abstract *Objectives:* This study investigated individual, community and district level factors associated with neonatal mortality among a national sample of Nepalese women.

Methods: Data were drawn from the 2006 Nepalese Demographic and Health Survey on women aged 15—49 who delivered within three years prior to the survey ($N = 4136$). Multilevel logistic regression models with three levels were fitted to assess the influences of measured individual, community and district level variables on neonatal mortality.

Results: The total neonatal mortality in three years preceding the survey was 4.5 deaths per 100 live births ($N = 190$), with neonatal mortality rate (NMR) = 46 per 1000 live births. Having a partner with no formal education, being in the middle on the wealth index and residing in less developed district were associated with neonatal death in bivariate analysis. Women who were assisted by skilled personnel during delivery were less likely to have neonatal death (adjusted OR for no assistance = 2.26, 95% CI = 1.19—4.26). Having prenatal care with skilled attendant was associated with less likelihood of neonatal death (adjusted OR for no care = 1.75, 95% CI = 1.17—2.62). Older women, mother's education, parity and wealth index were associated with neonatal mortality. Considerable variations in neonatal mortality at community and district levels were found.

Conclusions: These findings emphasize the need for interventions at the individual level with regard to access and utilization of healthcare in order to reduce the neonatal mortality in Nepal.

1. Introduction

Neonatal mortality is a global public health burden mostly concentrated in low- and middle-income

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countries. In low- and middle-income countries, where skilled professionals attend to fewer than half of the deliveries and where each year 60 million births occur outside health facilities [1], the burden of neonatal morbidity and mortality remains high [2]. Newborn deaths, that is deaths in the first four weeks of life (neonatal period), account for 41% of all child deaths before the age of five [3]. The first week of life is the riskiest week for newborns [3] and yet many low- and middle-income countries do not have comprehensive postnatal care programs to reach mothers and babies at this critical time [3].

Maternal and child health programs are beginning to place greater emphasis on newborn survival [4], but missed opportunities remain even in existing programs. There are, for example, midwives who are not trained and equipped for simple newborn care and neonatal resuscitation. Significant reductions have been seen in child mortality rates in Nepal over the last decades, but the neonatal mortality is still high compared with other low- and middle-income countries [5]. Similarly, maternal mortality rates are also high due to weak health care system with limited access to emergency obstetric care, lack of skilled attendants and the overall poor status of women. In developing countries, high neonatal mortality rates are due in part to lack of community awareness of appropriate care of the newborn [6]. In Nepal, primary and secondary care is deficient [7]. Most women have no antenatal care and most deliveries occur at home [8]. Most stillbirths and neonatal deaths also occur at home [9]. Thus, many might be avoided with changes in prenatal and newborn care practices.

Recent reviews of the evidence have shown that many neonatal deaths, especially early neonatal deaths (deaths within the first week of birth), can be prevented through evidence-based interventions [4,10], such as family-community care and an immediate neonatal care package [10], which require clinically trained providers. Darmstadt et al. [10] estimated that a skilled birth care package could reduce neonatal mortality by 20—30%. To adopt a focused, evidence-based approach to reduce neonatal mortality in Nepal, a clear understanding of the associated factors is necessary. In this paper, existing 2006 Demographic and Health Survey (DHS) data from Nepal were used to assess the factors associated with neonatal mortality. This study also investigated whether community and district-level factors have any influence on neonatal mortality.

2. Subjects, materials and methods

2.1. Data sources

The data for this study were adopted from the 2006 Nepal Demographic Health Survey (NDHS) conducted by the Department of Health Services, Population Division of the Ministry of Health and Population, and implemented by New ERA, a local research organization. Macro International Inc. provided technical assistance through its MEASURE DHS project. This study employed a nationally representative sample from households. A total of 10,973 women were identified as eligible for the individual interview, but the interviews were completed for 10,793 ever-married women aged 15—49, yielding a response rate of 98%. The present analysis is restricted to the 4136 women who had given birth within three years preceding the survey.

2.1.1. Description of the survey

The NDHS 2006 survey used the sampling frame from the 2001 census (Center Bureau of Statistics, 2001). Each of the 75 districts in Nepal is subdivided into Village Development Committees (VDCs), and each VDC is then divided into wards. The primary sampling unit (PSU) for the 2006 NDHS was a ward, sub-ward, or group of wards in rural areas, and sub-wards in urban areas. The sample for the survey was based on a two-stage sampling. At the first stage of sampling, 260 PSUs (82 in urban areas and 178 in rural areas) were selected using systematic sampling with probability proportional to size. A complete household listing operation was then carried out in all the selected PSUs to provide a sampling frame for the second stage selection of households. At the second stage of sampling, systematic samples of about 30 households per PSU on the average in urban areas and about 36 households per PSU on the average in rural areas were selected in all the regions in order to provide statistically reliable estimates of key demographic and health variables. The total sample is weighted, and a final weighting procedure was applied to provide estimates for the different domains, and for the urban and rural areas of the country as a whole. There was no need for ethical clearance for the current analysis.

2.2. Measurement of variables

2.2.1. Neonatal mortality

The neonatal mortality rate presented in this study was computed from information gathered in the

pregnancy history section of the Women's Questionnaire. Women in the age group 15–49 years were asked about the survival status of the children born three years preceding the interview. If a child was not alive, the age at death was recorded. Neonatal mortality is the probability of dying within the first month of life. The question on neonatal death had a binary response (No or Yes).

2.2.2. Birth attendants

Type of assistance (birth attendant) during delivery was measured by the question, 'Who assisted with the delivery of (NAME), and the responses were: (a) health professional (doctor, nurse/midwife, health assistant/health worker); (b) MCH worker, village health worker (VHW); (c) traditional birth attendants FCHV; (d) relatives or friends; or (e) no attendants. In the present analysis the responses were categorized into *skilled attendants*, that is, health professionals, *traditional trained attendants*, which include MCH workers and VHWs, *traditional untrained attendants*, which include FCHV and relatives or friends, and *no attendants*.

2.2.3. Prenatal care visits

Prenatal care visits during pregnancy were measured by the question, 'Did you see anyone for prenatal care for this pregnancy?' The responses were: (a) visit to health professional (doctor, nurse/midwife, and health assistant/health workers); (b) visit to MCH worker, village health worker (VHW); (c) visit to traditional birth attendants FCHV; (d) other person; and (e) no visits. In this study, the responses were categorized into *visits to skilled personnel*, which include health professionals, *visits to traditional trained attendants*, which include MCH workers and VHW, *visits to traditional untrained attendants*, which include FCHV and relatives or friend, and *no visits*.

2.2.4. Socio-demographic variables

Socio-demographic variables considered in this study include: age (15–20 years, 21–25 years, 26–30 years, >30 years); place of residence (rural, urban); educational level (no education, primary, secondary, higher); partner's educational level (no education, primary, secondary, higher); number of children (parity) (one, two, three, four, more than four); occupation (farmer, non-farmer, not working); religion (Hindu, non-Hindu); smoking status during pregnancy (no, yes); and wealth index. To keep the analysis simple and to ensure better interpretation, farmers were categorized as one, and all others were added to non-farmer. The wealth index was calculated using easy-to-collect data on a household's ownership of selected assets, such as televisions and bicycles, materials used for housing construction and types of water access, and sanitation facilities. The wealth index was generated from principal component analysis. It places individual households on a continuous scale of relative wealth. It was then categorized into five (poorest, poorer, middle, richer, and richest). The details of this questionnaire can be found at (http://www.measuredhs.com/pubs/pdf/FR191/FR191.pdf).

At the community level, the role of place of residence was assessed. Place of residence was defined as urban or rural. One district-level variable – density of health institution to the population in the district of residence – was included. Large inequalities in terms of availability of health facilities and human resources exist between districts. The ratio of public health centers to population was used as a proxy for the availability of health services in the district [11]. Determinants of neonatal mortality were based on the information from the existing literature [12–14].

2.3. Statistical analysis

The descriptive statistics were calculated first. Neonatal mortality rate (NMR), the number of deaths of neonates less than 28 days of age per 1000 live births, was calculated for each of the maternal background variables and the main determinant variables (birth attendants and prenatal care). Odds ratios (OR) and at 95% confidence intervals were also calculated for neonatal death using bivariate logistic regression analysis. To take into account the hierarchical structure of the sample where individuals are nested within communities (VDCs) and communities within districts, a multilevel logistic regression modeling was applied in this study [15,16]. Multilevel model with three levels was fitted to assess the influences of measured individual, community and district level variables (fixed effects) on neonatal mortality. In addition, community and district level random effects were estimated using the mlogit command in Stata 11 (Stata Corp Inc., TX, USA). In three-level logistic regression models the variance partition coefficient (VPC) was calculated as: $VPC_d = \sigma_d^2/(\sigma_d^2 + \sigma_c^2 + 3.29)$ and $VPC_c = \sigma_d^2 + \sigma_c^2/(\sigma_d^2 + \sigma_c^2 + 3.29)$ where σ_c^2 represents community level variance and σ_d^2 represents the district level variance. It gives how much of the variance is explained at the community or district levels. For the outcome variable (neonatal mortality), four models were estimated. In model I

(empty model) no determinant variables were included. This model represented the total variance of neonatal mortality between communities and district. In model II, only two major determinants (birth attendants and prenatal care) were included. Model III included all the individual level variables. Model IV was about the effects of community and district level variable, including all individual variables adjusted simultaneously. In order to simplify the presentation of the findings, only Models I, II and V are presented in the results. The results of fixed effects are shown as odds ratios (ORs) at 95% confidence interval (CI). The results of random effects are presented as variance. The random part of the models was estimated by computing the variance of the area-level variations and their accompanying standard errors.

3. Results

The overall neonatal death rate in the three years preceding the survey was 4.5 per 100 live births (N = 190), with neonatal mortality rate (NMR) = 46 per 1000 live births. Table 1 shows the distribution of neonatal death and NMR and bivariate association of neonatal death with maternal demographic characteristics. Women delivering at a younger were more likely to have a lower NMR compared with older women. Almost two thirds of the women had no education, and they also had the highest neonatal mortality (NMR = 56), while women with higher education had the lowest neonatal mortality (NMR = 16). About one fifth of the partners of the women had no education, and women of those partners also had the highest NMR (63). The bivariate analysis also showed that women whose partners had no formal education had a higher likelihood of having neonatal mortality (OR = 2.12, 95% CI = 1.10—4.08). The neonatal mortality rate was highest among women who had only one child (NMR = 53) and lowest among those with more than 4 children (NMR = 32). Women with farming occupation had the highest neonatal mortality (NMR = 49) among the occupational categories (non-farmers and women who did not work). Similarly, women who were in the middle of the wealth index had the highest neonatal mortality (NMR = 62), whereas, the poorest group had an NMR of 50, and the richest group had an NMR of 34. The bivariate analysis also showed that women of middle wealth index had a higher likelihood of neonatal mortality (OR = 1.89, 95% CI = 1.13—3.15). There was little difference between the NMR among smoking mothers (NMR = 48) and non-smoking mothers (NMR = 46); 76% of women were residing in rural areas, and had a similar NMR with those who resided in urban areas. By density of health institution, less developed districts had the highest NMR (54), while most developed districts had 40 NMR. Women residing in less developed districts had a higher likelihood of having neonatal death (OR = 1.92, 95% CI = 1.12—3.21) in the bivariate analysis.

Table 2 shows the distribution of NMR by health care services used by mothers during pregnancy and delivery. Women who did not have any birth attendants had the highest neonatal mortality (NMR = 89), while those who delivered with skilled attendants had the lowest (NMR = 37). Similarly, women who had no prenatal care had the highest neonatal mortality (NMR = 67).

3.1. Multilevel models

There was a considerable amount of variation in neonatal deaths across communities and districts. Table 3 shows the results of the final model when individual, community and district-level variables were computed together, including both fixed and random effects. When controlled for individual, community and district-level factors, the variances for the neonatal deaths in the final model (Model II) were lower than those in the empty model (Model I). Neonatal deaths attributed to the differences across communities and districts were reduced to 6.6% and 2.5%, respectively, in the final model (Model II). Women who had no assistance during delivery (no attendants) had a higher likelihood of having neonatal death compared with those who had skilled attendants (OR = 2.26, 95% CI = 1.19—4.26); having no prenatal care was associated with neonatal death (OR = 1.75, 95% CI = 1.17—2.62); higher age of women was associated with a higher likelihood of neonatal death; and Mother's education was significantly associated with neonatal death. However, after controlling for communities and district-level variables, the association lost its significance. Furthermore, higher parity was significantly associated with neonatal death. Women who were in the middle on the wealth index quintiles had a higher likelihood of having neonatal mortality. However, there was no statistically significant association found in the regression analysis.

4. Discussion

This study revealed that neonatal mortality is high in Nepal, and the presence of skilled health professionals in prenatal care and during delivery was

Table 1 Social-demographic characteristics of mother, neonatal death and neonatal mortality rate (NMR) and univariate odds ratio with 95% confidence interval for neonatal death, Nepal Demographic and Health Survey, 2006.

	N = 4136	Neonatal death (%)	NMR	OR 95% CI[a]
Mother's age (years)				
15–20	506	19 (3.8)	38	1.0
21–25	1438	66 (4.6)	46	1.23 (0.73–2.07)
26–30	1117	54 (4.8)	48	1.30 (0.76–2.22)
>30	1075	51 (4.7)	47	1.27 (0.74–2.18)
Education				
No education	2426	136 (5.6)	56	3.65 (0.89–14.92)
Primary	731	26 (3.6)	36	2.26 (0.53–9.67)
Secondary	854	26 (3.0)	30	1.93 (0.45–8.23)
Higher	125	2 (1.6)	16	1.0
Partner's education				
No education	957	60 (6.3)	63	**2.12 (1.10–4.08)**
Primary	1162	58 (5.0)	50	1.66 (0.86–3.21)
Secondary	1657	61 (3.7)	37	1.21 (0.62–2.32)
Higher	360	11 (3.1)	31	1.0
Parity				
1	1159	61 (5.3)	53	1.69 (0.98–2.93)
2	1180	55 (4.7)	47	1.49 (0.86–2.60)
3	752	36 (4.8)	48	1.53 (0.85–2.76)
4	508	21 (4.1)	41	1.31 (0.68–2.53)
>4	537	17 (3.2)	32	1.0
Occupation				
Farmer	2752	135 (4.9)	49	1.0
Non-farmer	640	27 (4.2)	42	0.85 (0.56–1.30)
Not working	744	28 (3.8)	38	0.75 (0.50–1.14)
Wealth index				
Poorest	1102	55 (5.0)	50	1.0
Poorer	854	37 (4.3)	43	1.12 (0.64–1.95)
Middle	738	46 (6.2)	62	**1.89 (1.13–3.15)**
Richer	765	29 (3.8)	38	1.28 (0.75–2.18)
Richest	677	23 (3.4)	34	1.49 (0.90–2.45)
Religion				
Hindu	3591	166 (4.6)	46	1.0
Non-Hindu	545	24 (4.4)	44	0.95 (0.61–1.47)
Smoking				
No	3511	160 (4.6)	46	1.0
Yes	625	30 (4.8)	48	1.05 (0.70–1.57)
Residence				
Urban	988	46 (4.7)	47	1.0
Rural	3148	144 (4.6)	46	0.98 (0.69–1.37)
District				
Most developed	1328	53 (4.0)	40	1.0
Intermediate	1164	49 (4.2)	42	1.06 (0.72–1.57)
Less developed	1644	88 (5.4)	54	**1.92 (1.12–3.21)**

[a] Statistical significant figures are marked in bold.

associated with a lower risk of neonatal death. The use of maternal health services is low in Nepal. Several individual, community and district-level factors were associated with neonatal mortality.

Nearly half of Nepalese women who attended prenatal care visits were attended to by skilled healthcare professionals, and 27% of women had no prenatal care at all. Furthermore, only 23% were

Table 2 Descriptive statistics and univariate odds ratio (OR) and 95% confidence interval (CI) for neonatal death due to birth attendance during delivery and prenatal care during pregnancy, Nepal Demographic and Health Survey 2006.

	N = 4136	Neonatal death	NMR	OR 95% CI[a]
Birth attendants				
Skilled attendants	954	35 (3.7)	37	1.0
Trained traditional	650	29 (4.5)	45	1.22 (0.74—2.02)
Untrained traditional	2219	98 (4.4)	44	1.21 (0.81—2.02)
No attendants	313	28 (8.9)	89	**2.58 (1.54—4.31)**
Prenatal care				
Skilled personnel	1968	74 (3.8)	38	1.0
Trained traditional	600	26 (4.3)	43	1.15 (0.73—1.83)
Untrained traditional	420	13 (3.1)	31	0.81 (0.44—1.48)
No prenatal care	1148	77 (6.7)	67	**1.84 (1.32—2.55)**

[a] Statistical significant figures are marked in bold.

attended to by a skilled health professional during delivery and 7.5% of women did not have any birth attendants. The multilevel analysis has shown that individual-level, community-level and district-level factors are important factors associated with both the use of maternal healthcare services and neonatal mortality in Nepal. However, the community-level and district-level variables used in this analysis were not found to be significantly influential factors for neonatal death. In the multilevel analysis the presence of skilled birth attendants during delivery, prenatal care visits, younger maternal age and low parity were significant predictors of low neonatal death.

Significantly higher neonatal death among the mothers who had no birth attendants during delivery, as well as those who had no prenatal care visits, were found in this study. No statistically significant differences were found in neonatal mortality whether birth was attended to by trained or untrained traditional birth attendants in accordance with other previous studies [17]. In low- and middle-income countries, especially in rural settings with limited access to healthcare, traditional birth attendants are an essential source of obstetric care [18]. Traditional birth attendants are also successful community health educators and breastfeeding counselors [19], and they can also influence neonatal mortality. The influence of these traditional birth attendants is likely to be related to their skills and knowledge; hence, to understand the relationship found here, there is the need to explore the level of traditional birth attendants in Nepal in dealing with delivery and prenatal care.

The results of this study support the findings from a previous study that neonatal death was reduced by 60% for those infants born with the assistance of skilled birth attendants in Indonesia [20]. Regular prenatal care visits are also an important determinant of a safe delivery because it offers opportunities to encourage women to deliver with a skilled attendant in a health facility [21], and consequently minimize neonatal mortality. It was found that women who had no prenatal care visits had a higher probability of neonatal mortality compared with those who had prenatal visits with skilled birth attendants.

Unexpectedly, this study showed that women in the older age group had a significantly higher risk of neonatal mortality. On the contrary, a previous study from Nepal has shown that infants from older women were less likely to die before reaching their first birthday [14]. It is worth noting, however, that Adhikary and Sawangdee [14] used a different age categorization. Studies, for example, by Neupane and Doku [8] have shown that in developing countries older women are less likely to deliver at health facilities or in the presence of skilled personnel. This could explain in part the findings of a higher likelihood of neonatal mortality among older women in Nepal.

In this study, it was found that the probability of neonatal mortality increases with parity. It could be because as the family size grows, the parental resources might be insufficient to maintain the proper level of nutrition for more children, and the mother herself could be undernourished during pregnancy. Strong associations have previously been reported between birth rank and the risk of neonatal death [20,22,23].

Although the association was not statistically significant in bivariate analysis, women with no education had higher odds of neonatal mortality. The higher a woman's education, the higher is the likelihood of her being informed about health is-

Table 3 Adjusted odds ratios (OR) and 95% confidence interval (CI) estimates for multilevel logit model of neonatal mortality during 3 years preceding to survey, Nepal Demographic and Health Survey 2006.

Variables	Model I[a]	Model II[b] OR (95% CI)	Model III[c] OR (95% CI)	Model IV[d] OR (95% CI)[e]
Birth attendance				
Skilled attendants		1.0		1.0
Traditional trained		1.14 (0.67—1.94)		1.01 (0.57—1.80)
Traditional untrained		1.00 (0.65—1.54)		0.96 (0.60—1.55)
No attendance		**1.99 (1.12—3.54)**		**2.26 (1.19—4.26)**
Prenatal care visits to				
Skilled attendants		1.0		1.0
Traditional trained		1.10 (0.68—1.78)		1.17 (0.70—1.93)
Traditional untrained		0.78 (0.42—1.45)		0.77 (0.40—1.46)
No care		**1.69 (1.16—2.45)**		**1.75 (1.17—2.62)**
Mother's age (years)				
15—20			1.0	1.0
21—25			1.53 (0.88—2.67)	1.48 (0.85—2.58)
26—30			**2.05 (1.10—3.81)**	**1.96 (1.05—3.64)**
>30			**2.59 (1.30—5.14)**	**2.45 (1.23—4.85)**
Education				
Higher			1.0	1.0
Secondary			2.45 (0.52—11.33)	2.50 (0.53—11.64)
Primary			2.99 (0.60—14.84)	2.89 (0.57—14.57)
No education			4.79 (0.98—23.30)	4.59 (0.92—22.80)
Partner's education				
Higher			1.0	1.0
Secondary			0.87 (0.41—1.85)	0.86 (0.40—1.84)
Primary			1.13 (0.51—2.53)	1.06 (0.47—2.38)
No education			1.49 (0.66—3.36)	1.37 (0.60—3.13)
Parity				
1			1.0	1.0
2			1.60 (0.81—3.14)	1.76 (0.88—3.48)
3			**2.34 (1.22—4.51)**	**2.71 (1.39—5.28)**
4			**3.23 (1.64—6.34)**	**3.90 (1.96—7.77)**
>4			**4.99 (2.44—10.20)**	**6.36 (3.04—13.32)**
Occupation				
Farmer			1.0	1.0
Non-farmer			1.23 (0.84—1.79)	1.21 (0.81—1.80)
Wealth index				
Richest			1.0	1.0
Richer			0.83 (0.44—1.55)	0.90 (0.47—1.72)
Middle			1.22 (0.66—2.25)	1.36 (0.70—2.61)
Poorer			0.78 (0.41—1.48)	0.85 (0.43—1.68)
Poorest			0.89 (0.46—1.72)	0.85 (0.42—1.73)
Religion				
Hindu			1.0	1.0
Non-Hindu			1.12 (0.70—1.80)	1.06 (0.65—1.71)
Smoking				
No			1.0	1.0
Yes			1.06 (0.68—1.65)	1.17 (0.75—1.84)
Community level variable				
Type of residence				
Urban				1.0
Rural				1.36 (0.86—2.15)

Table 3 (continued)

Variables	Model I[a]	Model II[b] OR (95% CI)	Model III[c] OR (95% CI)	Model IV[d] OR (95% CI)[e]
District level variable				
Health institution density				
Most developed				1.0
Intermediate				0.92 (0.56—1.51)
Least developed				1.35 (0.87—2.10)
Model statistics				
-2 log likelihood	−769.010	−757.127	−744.770	−730.164
Variance of random part				
Community level variance (SE)	0.191 (0.153)	0.214 (0.154)	0.179 (0.152)	0.147 (0.150)
Community level VPC (%)	6.2	6.7	6.1	6.6
District level variance (SE)	0.028 (0.094)	0.023 (0.090)	0.038 (0.094)	0.086 (0.098)
District level VPC (%)	0.8	0.7	1.0	2.5

SE: Standard error
VPC: Variation partition coefficient
[a] An empty model estimating the contextual variation in neonatal mortality.
[b] Model simultaneously adjusting for birth attendants and prenatal care visits.
[c] Model simultaneously adjusting for maternal characteristics: maternal age, maternal education, partner's education, parity, occupation, wealth index, religion and smoking status.
[d] Model simultaneously adjusting for all the variables in Model II plus Model III and community and district level variables: type of residence and health institution density.
[e] Statistical significant figures are marked in bold.

sues, including the use of healthcare services [24,25]. Partner's education had a significant influence on neonatal mortality. However, this was not confirmed by the multivariate analysis in this study. A previous study from Nepal had found that infants born to Hindu and Muslim women were more likely to die than the infants of Buddhist women [14]. Place of residence was not found to be associated with neonatal mortality in this study. However, this study showed substantial influence of health institution densities at the district level on neonatal mortality in bivariate analysis.

This study has several strengths. First, the data used for this study were from the demographic health survey, which is a nationally representative survey using standardized methods that achieved high individual (98%) and household (99%) response rates. The second strength of this study lies in the use of the random effect multilevel modeling that investigated the hierarchical structure of the data [26]. Despite these compelling strengths of the study, the following limitations should be noted when interpreting the results of this study. Data were self-reported. Also, as information on each outcome and determinants was collected retrospectively, there could be recall bias. The data used for this analysis were from a cross-sectional survey; therefore, conclusions about causality cannot be drawn. The effect of communities and districts could be better explained if there were enough community level and district-level variables in the data set.

5. Conclusions

The associations between neonatal mortality and individual, community and district-level variables were investigated. At the individual level, delivery without birth attendants, no prenatal care visits, higher maternal age, women whose partners had no formal education and higher parity were associated with neonatal mortality. Little variation at community and districts levels accounts for the differences in neonatal mortality.

At the individual level, where odds of neonatal mortality are significantly higher, the clinical skills of the birth attendants and prenatal care visits to skilled attendants have a significant impact on reducing neonatal mortality. Women whose partner had no formal education and parity were the most important factors associated with neonatal mortality. Therefore, empowering women and promoting partners' as well as mothers' education would be critical in reducing

neonatal mortality. In order to reduce neonatal mortality, utilization of health care services is most important. Particularly, individual level interventions targeting risk factors such as maternal age, wealth and the type of birth attendant should be intensified.

6. Competing interests

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

7. Ethics approval

Ethical approval for the survey was obtained from the national health and research council, and permission to use the Nepal Demographic and Health Survey data was obtained from Macro International, Inc.

8. Author contributions

S.N. designed and led the statistical analysis; S.N. and D.T.D. interpreted the results and drafted the manuscript. D.T.D. revised the manuscript for important intellectual content and both authors approved the final version of the manuscript.

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