Determinants of Neonatal Mortality in Rural Haryana: A Retrospective Population Based Study

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Objective: To identify the determinants of neonatal mortality.

Study design: Nested case-control study.

Study setting: 28 villages under the intensive field practice area of Comprehensive Rural Health Services Project, Ballabgarh, Haryana serving a population of 87,016, as on 31st December 2009. The study period was from 2005 to 2009.

Methods: The data were obtained from Health Management Information System and analyzed using multivariate logistic regression analysis. A hierarchical approach was used to analyze the factors associated with neonatal deaths, using community level factors, socio-economic status and biological determinants. The population attributable fractions were estimated for significant variables.

Results: The total live births during the study period were 10392 and neonatal deaths were 248. The infant and neonatal mortality rates during the study period were 45.6 and 23.8 per 1000 live births, respectively. Socio-economic determinants (Low educational status of parents [OR 2.1, 95% CI; 1.4, 3.3]; father's occupation [OR 1.8, 95% CI; 1.0, 3.0]; Rajput caste [OR 2.0, 95% CI; 1.2, 3.4] appeared to explain a major fraction (45.7%) of neonatal deaths. Community level factors (villages with no health facility [OR 1.5, 95% CI; 1.0, 2.1]; villages with population >6000 [OR 1.7, 95% CI; 1.2, 2.5]) were associated with 27.3% of all neonatal deaths. Proximate determinants (early childbearing age of mother (<20 years) [OR 2.0, 95% CI; 1.2, 3.2]) were least important. All the three level of variables seemed to act independently with little mediation among them.

Conclusion: Neonatal mortality is affected by socioeconomic, community level and proximate biological determinants.

Key words: *Determinants, India, Neonate, Mortality, Rural, Prevention.*

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Neonatal mortality rate (NMR) in India was 39 per 1000 live births in the year 2005-06, with rural and urban rates being 42.5 and 28.5 per 1000 live births, respectively [1]. There was only a decrease of 20.4 % in the National NMR from 1992-93 (49 per 1000 live births) to 2005-06 (39 per 1000 live births) [1]. The reduction of NMR largely requires intervention which is different from that required for reduction of post-neonatal mortality rate. The difficulty in reducing NMR has been documented from Jamkhed [2]. We conducted this study to understand the determinants of NMR in rural Haryana and the pathways through which these act.

METHODS

We carried out a nested case control study of live births that occurred between 1 January 2005 and 31 December 2009 (n = 10392) in the 28 villages in Ballabgarh under the Comprehensive Rural Health Services Project (CRHSP). Data were abstracted on live births and their outcomes from the Health Management Information System (HMIS). The health workers generate data at the village level where the service provision is done and on their monthly visits to Ballabgarh, transfer the data to the HMIS.

Every year annual census is carried out in December where 100% verification of data is done. Census is done by the health workers and is supervised by the health assistants and medical officer-in-charge, Primary Health Centre. For quality control, information in 20% households is cross-checked by the health assistant and in another 5% of the households by the Medical Officer in charge, for completion and accuracy. The reliability and validity of data is also verified by external users i.e. either investigators of research project or postgraduates of the study Institution. In an ongoing project at the study area, research workers collected demographic data and it was identified that in more than 95% of the fields, the demographic information in the HMIS was accurate.

Conceptual framework: The Mosley and Chen conceptual framework for the study of child survival in developing countries [3] was adapted based on selected possible predictors of neonatal mortality, which were restricted to those on which information was available in the HMIS. The Mosley and Chen framework is based on the idea that all community and socioeconomic determinants of child mortality operate through a set of biological or proximate determinants to affect a child's probability of survival [4]. The adaptation was based on our hypothesis that apart from mediating through the biological determinants, the community level and socioeconomic factors may also act directly to affect the neonatal outcome.

Study variables: The primary outcome was neonatal death, which was the death of a live born infant in the first four weeks of life. In the descriptive analyses, the neonatal mortality rate, defined as the number of neonatal deaths per 1000 live births, was used. The explanatory variables included community level contextual variables (population of village, distance of village from nearest secondary level hospital, availability of a primary health centre or a sub-centre in the village), socioeconomic (maternal education, paternal education, combined education of both parents, paternal occupation, caste) and proximate determinants (age of the mother at the time of childbirth, age of the neonate, sex, birth order, place of delivery) covering maternal, neonatal and delivery factors.

All the births and neonatal deaths that occurred during the study period were considered in the study. There were 10392 live births in which 248 deaths occurred in the neonatal period and 13 variables were used as determinants of mortality. The number of events i.e. neonatal death, per variable is 19 which suggest adequate events per variable (EPV) [5].

Statistical analysis: Data were compiled and extracted using MySql (Database Management Information System in Linux) for data analysis. Statistical analyses were carried out using SPSS 14.0 (Chicago, IL, USA) and Stata 9.0 (College Station, Texas, USA). To find factors associated with neonatal mortality, community level variables, socioeconomic determinants and proximate determinants were added in a stepwise process in the logistic regression analysis. All these three-level variables were scrutinized for multi-collinearity using Spearman correlation. At first level, only community level variables (Model-1) had been considered, in the second level socioeconomic determinants (Model-2) were added to model-1 and finally proximate determinants (Model-3) were added to Model-2 in the logistic regression analysis. The results were reported as odds ratio (95% CI). The Goodness-of-fit of each of the models was tested using Hosmer-Lemeshow goodness-of-fit statistic and the area under the receiver operating characteristics (ROC) curve was calculated for each model to assess model discrimination power of the model. *P* value less than 0.05 was considered statistically significant.

The variables found significant in each of the model were further evaluated for the proportion of neonatal deaths caused by it using population attributable fraction (PAF) or excess fraction with the formula: Pd * (RR-1)/ RR [6] where Pd is proportion of cases exposed to risk factor and RR is the relative risk which was calculated using OR derived from multivariable logistic regression using the formula: RR= OR/ [(1-P_o) + (P_o* OR)] where P_o is incidence of the outcome of interest in the non-exposed group [7]. Also, 95% confidence intervals for PAF were calculated using the formula: [Pd_L (RR_L-1/RR_L); Pd_U (RR_U-1/RR_U)]. The combined PAF for each level of the pre-defined conceptual model *i.e.* community level, socioeconomic determinants and proximate determinants were calculated using the formula: 1- {(1-PAF1) × (1-PAF2) × (1-PAF3).....} where PAF 1, 2, 3 etc represent the individual PAF of the variables (significantly associated with neonatal mortality in multivariable regression analysis) under each level [9,10].

RESULTS

The characteristics of the study variables at all the three levels are presented in ***Web Table* I**. *It also* summarizes the adjusted odds ratio ratios of the possible factors associated with neonatal mortality.

In the present analysis, neonatal mortality was influenced by factors from all the three levels. In Model 2, the odds associated with the community level factors did not change significantly compared to that in Model 1, upon inclusion of the socioeconomic factors. Moreover, in Model 3, it remained fairly the same as in Model 2 despite further incorporation of proximate determinants. Similarly, the odds for socioeconomic determinants in Model 2 did not show significant change upon inclusion of proximate variables in Model 3. This indicates that there was little mediation of distal variables through proximal variables. The area under the ROC curve was 0.5694, 0.6328 and 0.6456 for the Models 1, 2 and 3, respectively (***Fig.* 1**). Similarly, the P value for the Hosmer-Lemeshaw goodness of fit for Models 1, 2, and 3 were 0.01, 0.04 and 0.57, respectively.

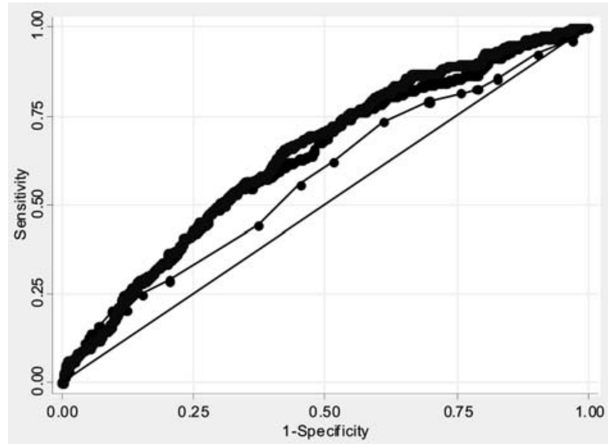
As can be seen from ***Table* I**, socioeconomic factors explained a large proportion of neonatal deaths with a PAF of 45.7%, and the large proportional contribution towards this was from low educational status of both the parents (34.7%). The PAF for early childbearing age of the mother (proximate factor) was not large (8.4%), while community level factors explained a total of 27.3% of all neonatal deaths.

DISCUSSION

There has been no significant decrease in the NMR in the study area over a period of 10 years *i.e.* from 2000-2009, though there have been fluctuations, with a lowest level in the year 2000 (17 per 1000 live births) and highest in the year 2004 (31 per 1000 live births). The NNMR during the study period *i.e.* 2005-2009 was 23.8 per 1000 live births. The important causes of neonatal mortality in the study area from the year 2002-2008, as determined by using verbal autopsy tool, were low birthweight (32.6%), birth asphyxia (22.7%), sepsis/pneumonia (16.6%) and congenital malformations (10.2%) (unpublished information).

The results of this study show that, the occurrence of neonatal deaths was a multifactorial process in the sense that is was related to a number of factors at community level, family level (socio-economic) and biological level (proximate). In our results, socioeconomic determinants explained a large proportion of neonatal deaths followed by community level factors and these factors, instead of working through proximate determinants seem to affect the neonatal outcome directly or through other factors which have not been included in the study.

The model 3 seems to be a valid model with Hosmer-Lemeshow goodness of fit having an associated *P* value >0.05. Also, the area under ROC curve was 0.64 which provides a fairly reasonable measure of this model to discriminate between those subjects who experienced outcome of interest i.e. neonatal death, *versus* those who did not. The reason for the other two models to be not a good fit might be because the number of variables/predictors included in model 1 and 2 were less as compared to model 3. The wide confidence intervals for the PAR can be due to the small sample size.



Model 1 ROC area: 0.569, 95% CI; 0.532, 0.606
Model 2 ROC area: 0.632, 95% CI; 0.597, 0.667
Model 3 ROC area: 0.645, 95% CI; 0.612, 0.678

FIG. 1 *Predictive ability of model 1, model 2 and model 3. Model 1 includes only community level determi-nants; Model 2 includes both community level determinants and socioeconomic determinants and Model 3 includes proximate determanants as well.*

Research in other areas of South Asia like Pakistan and Nepal, which share similar socio-cultural milieu, has demonstrated findings similar to our study. A study done by Imtiaz Jehan, *et al.* [11] in an urban Pakistani population found that neither delivery in a health facility nor by health professionals was associated with fewer neonatal deaths [11]. Another study done in Nepal identified early childbearing age of the mother as an important risk factor for neonatal deaths [12]. This finding

TABLE I POPULATION ATTRIBUTABLE FRACTION (PAF) WITH 95% CI, DERIVED FROM MULTIPLE REGRESSION ON RISK FACTORS FOR NEONATAL MORTALITY

	Model 1 PAF (%)	*Model 2 PAF (%)*	*Model 3 PAF (%)*
Community level factors	28.1	27.1	27.3
Village population >6000	17.3 (3.4, 30.2)	17.4 (3.1, 30.3)	17.9 (2.9, 30.2)
Non-availability of a health facility	13.2 (1.4, 24.7)	11.9 (-0.42, 23.8)	11.5 (-0.74, 23.6)
Socioeconomic determinants	NA	46.2	45.7
Low education of both parents	–	35.2 (14.4, 51.5)	34.7(13.3, 51.7)
Father occupation as labourer/ watchman/domestic servant/sweeper	–	6.5 (-0.40, 13.7)	6.5 (-0.37, 13.7)
Caste (Rajput)	–	11.2 (1.9, 20.2)	11.2 (1.8, 20.2)
Proximate determinants	NA	NA	8.4
Mother's age <20 yrs	–	–	8.4 (1.5, 15.7)

**PAF- Population Attributable Fraction; Model 1 includes only community level determinants; Model 2 includes both community level determinants and socio-economic determinants and Model 3 includes proximate determanants as well.*

WHAT IS ALREADY KNOWN?

- Previous studies on determinants of neonatal mortality have largely focused on biological determinants – like birthweight, parity, skill of birth attendant etc.

WHAT THIS STUDY ADDS?

- Our hierarchical model shows that the variation in neonatal mortality is explained more by family (socioeconomic) and community level determinants.

is further supported by a study done in rural Bangladesh where the researchers found early childbearing of the mother as a risk for perinatal deaths [13].

The strength of the study lies in that the data, because of being routinely collected, is likely to be not subjected to any bias. The other strength includes use of a conceptual framework and use of an appropriate model with different levels. However, the study had limitations that should be noted when interpreting the results. First, the study variables were limited to those available in the HMIS dataset. The two major group of factors affecting neonatal outcome would be those related to the knowledge, attitude and practices (KAP) of caregivers and proximate biological determinants like birthweight, gestation, attendance at birth by health care personnel skilled in resuscitation, breastfeeding etc. However, the focus of our study was not on biological determinants but to look at social and health system determinants. They have been adequately covered. Nevertheless, the results should be interpreted carefully as the lack of key proximate determinants might have assigned more importance to intermediate and distal risk factors.

Our current analysis shows that the important determinants of neonatal mortality lie at community, health system and social level. A multi-pronged strategy of health system strengthening, community mobilization, behaviour change is required to address neonatal issues in the country. The health system strengthening should not be restricted to public funded facilities but has to include in its ambit small private sector facilities where many deliveries occur in rural areas of India.

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Contributors: AK designed the study; RPU, PRD and MK performed the analysis and prepared the manuscript; AK, SKR and PM provided advice on data analysis and revised the final manuscript. All the authors read and approved the final manuscript.

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