**A Study of Association Between Maternal Tetanus Toxoid Immunization and Neonatal Mortality in the Context of Bangladesh**

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**Abstract**

**Background:** Maternal tetanus toxoid (MTT) vaccination during pregnancy remains an important factor for reducing infant mortality globally, especially in developing nations, including Bangladesh. Despite commendable progress in reducing child mortality through widespread MTT vaccination during pregnancy, the issue still exists. This analysis explores the impact of MTT vaccination on neonatal mortality in Bangladesh and identifies associated factors.

**Methods:** This research utilizes data from the 2019 Bangladesh Multiple Indicator Cluster Survey (MICS). The dataset consists of 23,402 cases, among them 587 cases resulted in the infant death. The outcome variable was infant mortality, which binary and the independent variables considered as potential factors for the cause of death being the tetanus toxoid vaccination status, birth by cesarean section or not, mother’s education level, etc. The Poisson model was employed to analyses data.

**Results:** The analyses showed that the neonatal mortality rate was 2.51%. Notably, 45.90% of mothers received MTT vaccination during pregnancy. Among them, 23.07% received a single dose and 22.82% took adequate doses (receiving more than two doses) and adhered to WHO guidelines. The crudeincidence rate ratio (IRR) was indicates that there was 19% higher risk of neonatal mortality for those children whose mother did not take TT ( and the adjusted IRR was 1.36, indicates 36.4% higher risk of neonatal mortality (adjusted IRR = 1.36, p = 0.081).

**Conclusion:** Maternal Tetanus Toxoid vaccination plays a crucial role in reducing child mortality. Other than MTT, the analyses underscores various contributors to neonatal mortality, encompassing maternal healthcare, vaccination, delivery procedures, socio-economic status, and education. Targeted interventions addressing these factors have the potential to efficiently decrease neonatal mortality rates and improve overall maternal and child health.

**Keywords:** Tetanus, tetanus toxoid vaccine, neonatal death, neonatal mortality, maternal tetanus, adequate doses.

**Introduction**

Neonatal tetanus is a life-threatening but preventable disease that develops when contaminated material is used to cover the umbilical stump or when non-sterile tools are used to cut the umbilical cord (1). This common bacteria lives in soil by nature, however, it can also be isolated from human and domestic animal feces (2). It can make surgery, intramuscular injections, gangrene, burns, ulcers, necrotic snakebites, middle ear infections, septic abortions, and childbirth more difficult (3).While tetanus can impact anyone, it is particularly severe in newborns and pregnant women who lack adequate tetanus-toxoid vaccinations, often leading to death or significant health issues (4).

Spores of *Clostridium Tetani* enter the human body through wounds or small abrasions when anaerobic conditions are met. Tetanus can be avoided whenever a wound arises with proper wound care and vaccination (5). However, t A major public health problem called maternal and neonatal tetanus (MNT) affects mothers and their newborns when they give birth in unhygienic surroundings and do not receive the full course of tetanus toxoid (TT) vaccinations. A baby is shielded from the disease for the first two months of life if the mother has received maternal and neonatal tetanus (MNT) protection (6).

Tetanus can be prevented by vaccination with tetanus-toxoid-containing vaccines (TTCV), which are typically given to reproductive women between the ages of 15 and 44 years to protect both mother and newborn and prevent maternal and neonatal tetanus. A woman needs five tetanus toxoid doses to be protected against tetanus for life (6). For children, the World Health Organization (WHO) recommends six doses of TTCV, three of which are primary and three of which are boosters. The three-dose primary series should start as early as six weeks of age, with the following doses spaced at least four weeks apart. Preferably, the three booster doses should be administered between the ages of 4 and 7 years, 12 and 23 months, and 9 and 15 years (7). Booster immunization campaigns are directed toward women of childbearing age, and in many nations, they have significantly decreased the incidence of tetanus in both mothers and newborns (5).

It has been challenging to enhance neonatal health in low-income countries because babies have less access to health care and are thus more at risk of worse health outcomes (8), for instance, a prior study discovered that 54.7% of newborn deaths happened during the neonatal period between 1997 and 2002 (9). A failure in routine prenatal immunization programs, below average antenatal care services, an increase in home deliveries, and unhygienic deliveries result in a mortality rate of about 35% and proximal (309000) deaths from maternal or neonatal tetanus (10). Tetanus caused an estimated 787,000 infant fatalities in 1988, with an estimated proportionate mortality rate of 6.7 per thousand live births, demonstrating the disease's significant contribution to the world's high rate of neonatal mortality (11). Globally, reported newborn tetanus mortality dropped by 85% between 2000 and 2018, from 170,829 to 25,000 deaths (12). Approximately 25,000 fewer newborns died in 2018 compared to 215,000 in 1999, a considerable decline since that year. Out of 59 low- and middle-income at-risk nations, MNT has currently been eradicated in 47 of them (13).

The Bangladesh Demographic and Health Survey reported neonatal mortality rates of 28 per 1,000 live births in 2014 and 30 in 2017, while under-five mortality rates were 46 per 1,000 in 2014 and 45 in 2017 (National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2014) (National Institute of Population Research and Training (NIPORT), Mitra and Associates, ICF International. Bangladesh Demographic and Health Survey 2017-18). The current rate is significantly higher than the global average of 6.6 per 1,000 live births in 2015 and exceeds the 7.4 per 1,000 averages in developing countries and neighboring countries like India and Nepal (https://pubmed.ncbi.nlm.nih.gov/30497986/). ~~In Bangladesh, during 2003-2004, there were 11,291 livebirths and 365 neonatal deaths in a rural district (14). Similar studies showed that about half of all deaths involving children under five that occurs in Bangladesh are infants, while the newborn mortality rate is 41 per 1,000 livebirths (15).~~ The WHO reports that preterm birth causes 30% of global neonatal deaths, sepsis or pneumonia 27%, birth asphyxia 23%, congenital abnormalities 6%, neonatal tetanus 4%, diarrhea 3%, and other causes 7% (<https://pubmed.ncbi.nlm.nih.gov/15752534/>) (<https://scholar.google.com/scholar_lookup?title=The+world+health+report:+2005:+make+every+mother+and+child+count&publication_year=2005&>) (https://pubmed.ncbi.nlm.nih.gov/15794969/). An exploratory study in rural Bangladesh found that tetanus accounts for 42% of newborn deaths (16). According to another study, out of 330 infant deaths, 112 of them fit the tetanus case description (17). Despite TT2's estimated 45% efficacy, maternal history of receiving two doses of the tetanus toxoid did not lower the risk in Bangladesh (16). ~~Another investigation that looked at 6748 neonatal fatalities throughout four districts in Bangladesh (Thakurgaon, Jamalpur, Moulvibazar, and Narail) with a combined population of 6.7 million found that there were 24.4 neonatal deaths for every 1000 live births (18).~~ Additional investigation is required to determine the pattern of declining infant mortality in Bangladesh following vaccination against maternal tetanus toxoid since there is no evidence related to this.

Tetanus is still prevalent and a major cause of death in low-income countries, despite considerable World Health Organization programs that effectively target maternal and newborn disease (19). As opposed to low-income countries (LICs), High-Income Countries (HICs) like the United States of America, England, and Denmark have long since managed tetanus-related newborn mortality (20). A few Low and Middle-Income Countries (LMICs), like Bangladesh, Afghanistan, and Nepal are also making progress in lowering neonatal tetanus fatality rates (11) , even though the pace of reduction is very low (21).

Effective intervention programs have been put in place in these nations, including better cord care, better tetanus toxoid coverage for expectant women, safe birth practices, and postpartum care procedures. Although there have been some successes in nations like Bangladesh and Nepal, LMICs continue to struggle with the reduction of infant mortality for neonatal tetanus. According to our knowledge, no study ever before able to give a clear picture of the influence of maternal tetanus toxoid vaccination in reducing neonatal mortality in Bangladesh. We aimed to examine the association between neonatal mortality and tetanus toxoid immunization among women aged between 15-49 in the context of Bangladesh. This stud will help the policymakers and planners to take more convenient and efficient steps regarding this vital issue.

**Materials and methods**

**Description of the dataset:**

This research was performed based on a cross-sectional study of the 2019 accessible data available from the Bangladesh Multiple Indicator Cluster Survey (MICS), which was carried out in 2019 from January 19 to June 1 by the Bangladesh Bureau of Statistics (BBS) with collaboration from United Nations International Children's Emergency Fund (UNICEF). The survey sample was chosen using a two-stage, stratified cluster sampling procedure to recruit the participants. The 2011 Bangladesh Census of Population and Housing served as the base for the sampling frame. The enumeration areas (EAs) chosen for the census enumeration were the primary sampling units (PSUs) chosen at the initial stage. In each sample EA, a household listing was completed, and in the second stage, a sample of households was chosen. The sample was created to give estimates of a broad variety of variables for women and children nationwide, including those for urban and rural locations throughout all 64 districts of the seven administrative divisions. The survey included a sample of 64,400 households and about 3,220 primary sampling units (PSUs) (22). Trained interviewers used questionnaires covering reproductive history, prenatal and postnatal care, family planning, and demographic characteristics to properly interview these households. Datasets were open access for the public domain (UNICEF MICS., “Surveys - UNICEF MICS,” MICS Surveys, 2018. https://mics.unicef.org/surveys).

Children who have died in the neonatal period or in the first month after birth may be considered eligible cases for participation. Furthermore, although they were still alive at the time of the survey, children who had a high risk of newborn mortality were specifically selected as study subjects. Births that took place before 2014 or five years before the survey are not considered cases.

**Study Variables**

The child's survival status in the neonatal stage, which is binary and classified as either 0 (for alive) or 1 (for death), is the outcome variable. The analysis employed data pertaining to the age at which mortality events occurred among live births that transpired during the five-year period immediately preceding the MICS 2019 survey. The variable identifying if the neonatal death occurred or not was recoded using the standard procedures following the SPSS syntax files for the 2019 survey provided by UNICEF (23). These data were utilized in the construction of the outcome variable for the research analysis.

The principal factor under investigation as a potential exposure variable was the administration of the tetanus toxoid vaccine, classified as either "0" for non-taken or "1" for taking at least 1 dose.Again, at least two doses are considered adequate according to the WHO.In addition to the principle factor, the additional modifiable risk factors analyzed in this research consisted of cesarean section (yes, no), gender of the neonate (boy and girl), antenatal care visits (less than 4, 4 and above), division (Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet), mother's education level (primary, higher secondary), birth order (1, 2, and 3), mother's age during pregnancy (15-20, 20-24, 25-29, 30-34, 35-39, 40-44, and 45-49), socioeconomic status (poorest, middle, and richest).

**Statistical Analysis**

Chi-square tests have been implemented to assess the relationship between potential exposure or control variables and infant mortality, forming the foundation for our models. Factors in bivariate models with p-value < 0.2 were included in the multivariable model, along with a previous multicollinearity test and this threshold for p-value has been taken from a previously published paper (24,25).

For highly skewed binary data with significant class imbalance, Poisson regression can be preferable over logistic regression. Poisson regression provides better performance due to its log transformation, which enhances stability and interpretability of results. This approach is particularly advantageous in cases of high skewness, as it offers reliable estimates and reduces the risk of overfitting. The Poisson model effectively estimates relative risk and manages variance overestimation, making it a robust choice for binary outcomes in such contexts (26,27). Our data's extreme imbalance and skewness align well with Poisson regression’s strengths. Therefore, the final analysis was carried out using a Poisson regression model to examine the relationship between the outcome variable and several predictor variables, since in our data the proportion of death is less than 5% (approximately 2.54%) indicating a high skewness in child mortality. The model included all variables deemed significant by chi-square analysis, ensuring a comprehensive examination of their impact on child mortality. The missing values were removed with case-wise deletion as per the default data handling procedure in STATA. For each predictor variable, the incidence rate ratio (IRR), and the 95% confidence interval (CI) for child deaths were calculated.

**Ethics Statement**

Our analysis was based on publicly available datasets of health surveys and removed all the personal information that could be identifiable. As the study analysis was made from a secondary source of data, it was exempt from ethical review approval from the respective institutions. However, MICS methods were reviewed and approved by both UNICEF and BBS.

**Results**

Data from the most recent MICS (2019) survey were incorporated into this research. Of the 23,402 neonatal births, 587 resulted in neonatal fatalities or, roughly 2.54% of all neonatal births (Fig 1). About 45.9% of women took at least one dose of tetanus toxoid immunization during their last pregnancy and 22.82% of women took adequate doses. Numerous variables contributed to early newborn deaths. For example, in the univariate analysis provided in Table 1, women who delivered (67.2%) by cesarean section dealt with higher neonatal deaths (3.1%) compared to normal deliveries (1.59%). It was also observed that neonatal mortality is higher in boys (2.7%) than in girls (2.3%) during delivery. Notably, neonatal mortality rates were 1.69% among mothers who had fewer than four ANC visits, whereas mothers who had four or more ANC visits experienced a slightly lower neonatal mortality rate of 1.21%. Additionally, a small portion of mothers (0.13%) indicated that they did not know the number of ANC visits. Interestingly, a significant relationship in univariate analysis has been found between division and neonatal mortality where mothers of Sylhet division had the highest neonatal mortality (3.7%). An additional point that can be noted is that education plays a significant role in neonatal mortality. Women who took primary or secondary education faced 2.7% neonate death and higher secondary level had 1.6%. Birth order also emerges as significant, with second-parity births associated with higher neonatal mortality, calling for a deeper exploration of underlying factors. Women with higher birth parity deal with higher neonatal mortality which is another significant factor. In terms of the wealth index of the respondents, 45.56% were from poor families, 37.2% were from the middle class, and 16.73% were from the rich. Among them the poorest deals with 2.9%, the middle 2.4%, and the richest 1.7% of neonatal mortality respectively. Last but not least, the majority of women in the 20–24 age range had a significant rate of newborn infant mortality (2.9%).

From Table 1, we get the row proportions of the mortality status in different categories of the covariates. Notably, from the table we see that the respondents in the poorest category of the wealth index have the highest proportion of neonatal deaths (2.9%) compared to the richest (1.7%) and middle class (2.4%). The proportion of neonatal mortality is also highest in the Sylhet division (3.7%) followed by the Rajshahi division (2.9%). The proportion of death is also highest in the 3rd parity or more (3.1%). Furthermore, the mothers who had natural birth have a higher proportion of neonatal deaths (4.8%) compared to mothers who had births by cesarean section (3.1%). Lastly, the vaccinated mothers with the tetanus toxoid vaccine had lower neonatal mortality (3.3%) as compared to non-vaccinated mothers during their last pregnancy (2.9%).

[Table 1 Here]

From the figures, we get an insight into the association and distribution among some variates. The first figure (Fig 2), The charts highlight the importance of tetanus vaccination in reducing neonatal deaths. Regions with higher vaccination rates among neonates, such as Barishal, show lower percentages of neonatal deaths. Conversely, areas like Sylhet, which have lower immunization rates, have a greater incidence of infant fatalities. This pattern underscores the critical role of tetanus vaccination in improving neonatal survival rates, as evidenced by the significantly lower mortality rates in areas with better vaccination coverage. (Fig 3) suggests that first parity births have the highest rate of vaccination and with subsequent births, the proportion of vaccinated individuals decreases. Relating this to Table 1, it is observed that the 3rd or higher parity births also have a higher proportion of neonatal deaths, implying the importance of vaccination. (Fig 4) represents the proportion of doses of tetanus toxoid vaccine taken by the mother, where the newborn faced a neonatal death. Further implying the significance of adequate tetanus toxoid vaccination, it is observed that, among the neonatal deaths, a significantly large proportion of mothers (56.8%) had taken no tetanus toxoid vaccine during pregnancy and only 19% of the mothers had an adequate amount of at least 2 doses of tetanus toxoid vaccine.

**Fig 1. Proportion of dead and alive neonates**

**Fig 2. Tetanus toxoid vaccination status across different divisions**

**Fig 3. Tetanus toxoid vaccination status among at different birth order**

**Fig 4. Proportion of administered tetanus toxoid doses**

The results of the regression analysis of the factors that predict newborn mortality are shown in Table 2. In the Poisson regression model including the variables with p <0.2, p<0.1, p < 0.05, p < 0.01, p < 0.001 in the univariate analysis, tetanus doses, women's education level, women with a higher index wealth quintile, women with a higher parity were found to be significantly linked with newborn mortality in the Poisson regression model. Crude incidence rate ratios (IRRs) for death are shown in the characteristics table for women who had tetanus toxoid (TT) immunization vs those who did not. When compared to the vaccinated group, the unvaccinated group's crude IRR for death was 1.185 at first, with a p-value of 0.18, indicating no discernible difference in mortality. However, after adjusting the other factors in the model, the crude IRR rose to 1.364 with a p-value of 0.08. Although this is not statistically significant at the traditional cutoff point of p < 0.05, this adjusted IRR suggests an elevated risk of MTT on infant mortality. According to our analysis, mothers with no tetanus dose had a 36.4% increased incidence rate ratio of experiencing newborn mortality (IRR= 1.364, 95%CI= 0.962, 1.934) compared to mothers taking at least a single tetanus dose. Interestingly, the cesarean section was found insignificant. We also discovered that women's education level was significantly associated with newborn mortality, where mothers with primary or secondary education had an increased 86% incidence rate ratio of newborn mortality (IRR =1.86, 95%CI = 1.16, 2.99) compared to mothers who had studied at the higher secondary level. Additionally, women from poor families had a significantly higher incident rate ratio compared to the women from rich families (IRR= 1.77, 95%CI =0.925,3.382). Similarly, women from middle-class families had a significantly higher incident rate ratio compared to the women from rich families (IRR= 1.579, 95%CI= 0.981,2.543). In addition, third parity births was found to be substantially correlated with newborn mortality when compared to the second parity births (IRR=1.961, 95%CI=0.954,4.031). This indicates that women with higher parity had a 96.1% increased risk of neonatal deaths. Women aged between 25 to 29 years indicated a fairly significant association (IRR= 1.89, p= 0.081) with newborn death, showing an 89% higher incident rate ratio of neonatal mortality compared to women aged between 30 to 35 years. Likewise, women aged between 45 to 49 years had significantly (IRR = 4.049, p = 0.055) higher rate ratio against women aged between 30 to 35 years. Gender, antenatal care visits and division which are the necessary factors, were found to be insignificant in the model. Similar trend has been found in the relationship between number of tetanus doses taken and neonatal mortality that is given as appendix 1, which also describes taking adequate doses (at least 2 doses of tetanus vaccine) reduce neonatal mortality (Crude IRR=0.865, 95%CI =0.568, 1.317) comparing to none taken host.

[Table 2 here]

**Discussion**

Tetanus poses a serious risk to life (28). Though remarkable progress has been made for the last two decades in lowering tetanus-related deaths globally, neonatal tetanus has received a lot of attention up to this point and very little is known to maternal tetanus (20,29). For this very reason, this survey is conducted to identify the result of neonatal mortality by taking tetanus toxoid vaccination among pregnant women aged between 15-49 years, and found that maternal vaccination is conspicuous factor in reducing neonatal death.

No studies have been conducted before to show the association between neonatal mortality and tetanus toxoid immunization along with other necessary covariates. Our main findings indicate that women who receive at least one dose of the tetanus vaccine significantly lower their child's risk of neonatal death. Additionally, approximately 2.54% of neonatal deaths in Bangladesh can be linked to pregnant women who did not receive at least one dose of the tetanus toxoid vaccination, and approximately 45.9% of women received at least one dose of the vaccine, which may be useful information for efforts to increase vaccination rates.

Our findings show that only 22.82% of pregnant women had received a sufficient amount of the TT vaccine, which is low as compared to a study showing that sufficient TT immunization among pregnant women was 75% worldwide (30). These findings are consistent with previous research's findings, which showed a lower prevalence of obtaining the adequate TT vaccine (17) and the rate of newborn death was 63.8 per 1000 live births (31). The prevalence of TT immunization was 81.8% for MICS (2006) and 61.3% for MICS (2012–2013) (32) and we observed in our research that for MICS (2019), the rate of taking tetanus doses was 54.1%. These findings shed light on the varying levels of vaccination coverage among pregnant women, emphasizing the need to promote and ensure full compliance with the WHO's recommended vaccination regimen during pregnancy for the optimal prevention of maternal and neonatal tetanus. Overall, in Bangladesh, the prevalence has generally been declining over the course of the survey years.

In our model, we discovered that tetanus doses taken, women's education level, wealth index, and birth order were significantly associated with higher odds of neonatal mortality. Our analysis shows that mother with no tetanus doses has the 36.4% more chance to experience neonatal death (IRR= 1.36, 95% CI= 0.96, 1.93) comparing to mother with at least 1 dose. Similar to other studies, we discovered that the TT vaccine had a protective effect against infant mortality when compared to IFA (iron–folic acid) supplementation alone (33–35). The evidence from India aligns with our analysis, indicating that receiving at least one dose of the TT vaccination could decrease infant death (36). Another study revealed a sharp decrease in newborn mortality as a result of a decrease in neonatal tetanus deaths (37). Tetanus vaccination coverage plays a vital role in reducing neonatal tetanus. As far as we are concerned, we are the first to show the association between tetanus toxoid vaccination and neonatal mortality in Bangladesh in recent years.

Cesarean section is a potential factor for neonatal mortality according to previous studies, where cesarean section delivery is highly correlated with neonatal mortality in low-income countries like Bangladesh (8,38). However, we find no association of neonatal mortality with cesarean sections, which may be a noticeable gap in our study that can be addressed with the confirmation of further research. A mother's education significantly plays a vital role in neonatal mortality. Women who only completed elementary or secondary school had a greater risk of newborn mortality compared to women who pursued higher education. Considering that educated women may be better empowered to make decisions about their health, education may increase their understanding of the harmful impacts of tetanus and neonatal death (32,39).

The health of the Bangladeshi population has significantly improved over the past 20 years, and Bangladesh has been acknowledged as an example of "good health at low cost" (40). As far as we are aware, socioeconomic status has a big impact and is highly correlated; babies from the "poorest" homes are more likely to die, which emphasizes how critical it is to solve socioeconomic gaps in access to healthcare. Our research says women with wealthy households are less likely to face neonatal mortality compared to women with a poor wealth quantile index. This result is in line with earlier research demonstrating that increasing the wealth index of women living at home protects against tetanus in comparison to a low wealth index (36,39,41,42) We believe that women from wealthy families are more likely to have access to healthcare services than women from low-income families. A policy and programming requirement to ensure that all pregnant women receive at least one dose of prenatal medication, especially those in need or marginalized population subgroups, is expected to have a significant influence on improving neonatal survival. This specific intervention should be within the grasp of the public health system as an immediate priority due to difficulties in providing the entire health system functionality needed for comprehensive and safe mother and newborn care (32).

Another important factor associated with neonatal mortality is higher parity. Our study revealed that women with higher parity have lower odds of neonatal mortality compared to those with lower parity. This is supported by findings from previous studies that have found higher parity to be a significant predictor of neonatal mortality (43–45). The past birth experiences of the ladies may be the cause. It's also reasonable that women with more children are less likely to be employed or to have greater levels of education. There are further studies that show older women in the nation are less likely than younger women to use prenatal and delivery care, which can be another identifiable reason (46–48).

**Limitations and Strengths**

**Strengths**

To our knowledge, this study is the first in Bangladesh to investigate the relationship between maternal tetanus toxoid vaccination and neonatal mortality. We employed appropriate data analysis techniques, taking into consideration all intricate survey designs. Findings from this work can be used to inform future research, policy, and clinical practice and to benchmark progress. One of the benefits of this study is the sizeable and nationally representative sample size, and the results are applicable to the entire country. The information was gathered using the most recent survey. Our results would surely pique interest in additional research and educate decision-makers about the gaps in tetanus care that need to be filled.

**Limitations**

However, despite the several strengths, the existence of bias resulting from different survey time points and the cross-sectional character of the data cannot be confirmed. Some variables that were statistically insignificant but still important for the research study have been considered in the model. It is crucial to keep in mind that the mortality that is being discussed here includes deaths from all causes. Regretfully, our analysis lacks particular data that isolates the risk exclusively for newborn mortality. Notwithstanding this restriction, the trend that has been seen points to a higher risk of death for those who have not had the TT vaccination, however statistical significance is not attained. This realization emphasizes how crucial it is to conduct additional studies to determine the specific effect of the TT vaccine on mortality outcomes, especially neonatal death. To offer more precise information, future research focusing on infant mortality rates and any confounding factors is required.

The level of significance was deemed to be fairly high. In addition, the study's drawback also emerges from the fact that we had little control over the correlated variables to include in the analysis due to the secondary data source we employed. Conclusions regarding a causal association, the relative contributions of immunization prior versus during the most recent pregnancy, or the best possible ways to increase coverage are not possible due to the cross-sectional character of this investigation. In addition, the dependent variable for newborn death has a large number of missing values, making it impossible to include them in the analysis. This could lead to bias, and the variable varies over time, potentially changing the claimed association in longitudinal studies.

**Conclusion**

Premature infant death is more common among Bangladeshi women with no tetanus toxoid vaccination. To the best of our knowledge gained from our findings, taking at least one maternal tetanus dose greatly reduces neonatal mortality, which clearly draw that increasing vaccination coverage as well as deploy mandatory law of taking at least one maternal tetanus dose can save infant at great number. According to our research, women who received tetanus shots had better education levels, belonged to the quintile with the highest family wealth, and had higher parity were all substantially associated with lower odds of newborn mortality. To decrease neonatal death for the betterment of a country like Bangladesh, we advise taking help from the government and other organizations in conducting immunization campaigns, increase vaccination coverage, and improving self-care through proper education and awareness.

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***Conflicts of interest***

The authors reported no potential conflict of interest.

***Author Contributions***

Conceived and designed the experiments: Md. Efty Islam Arpon, Sujan Kumar Naha. Performed the experiments: Sujan Kumar Naha, Md. Efty Islam Arpon. Analyzed the data: Sujan Kumar Naha, Mohammed Nayeem Hosaain, Md. Efty Islam Arpon. Wrote the paper: Md. Efty Islam Arpon, Sujan Kumar Naha, Rifa Tasfia Siddique, Farjana Rahman Ripa. Supervised by: Dr. Md. Jamal Uddin

The submitted article was authored by all contributors, who also provided their approval.

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**Table-1:** **The row-wise proportional distribution across various categories**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | **Neonatal mortality status** | | | | **Total**  **n (%)** | | **P-value** |
|  | | Dead  n (%) | | Alive  n (%) | |
| **TT vaccinated** | |  | |  | |  | |  |
| No | | 202(3.3) | | 5934(96.7) | | 6136(54.1) | | 0.255 |
| Yes | | 152(2.9) | | 5055(97.1) | | 5207(45.9) | |  |
| **TT doses taken** | |  | |  | |  | |  |
| none | | 202(3.3) | | 5934(96.7) | | 6136(54.1) | | 0.254 |
| 1 injection | | 84(3.2) | | 2532(96.8) | | 2616(23.1) | |  |
| 2 injections or more (adequate doses) | | 68(2.6) | | 2519(97.4) | | 2587(22.8) | |  |
| **Cesarean section** | |  | |  | |  | |  |
| Yes | | 117(3.1) | | 3687(96.9) | | 3804(67.2) | | <0.001 |
| No | | 90(4.8) | | 1769(95.2) | | 1859(32.8) | |  |
| **Gender** | |  | |  | |  | |  |
| Boy | | 330(2.7) | | 11776(97.3) | | 12106(51.7) | | 0.028 |
| Girl | | 257(2.3) | | 11039(97.7) | | 11296(48.3) | |  |
| **Antenatal care (ANC) visits** | |  | |  | |  | |  |
| Less than 4 | | 154(3.0) | | 5053(97.0) | | 5207(57.1) | | 0.077 |
| Above 4 | | 110(3.0) | | 3591(97.0) | | 3701(40.6) | |  |
| Don’t know | | 12(5.7) | | 200(94.3) | | 212(2.3) | |  |
| **Division** | |  | |  | |  | |  |
| Barisal | | 49(2.4) | | 2020(97.6) | | 2069(8.8) | | 0.004 |
| Chittagong | | 119(2.4) | | 4778(97.6) | | 4897(20.9) | |  |
| Dhaka | | 91(2.0) | | 4508(98.0) | | 4599(19.7) | |  |
| Khulna | | 70(2.2) | | 3158(97.8) | | 3228(13.8) | |  |
| Mymensingh | | 37(2.7) | | 1341(97.3) | | 1378(5.9) | |  |
| Rajshahi | | 71(2.9) | | 2379(97.1) | | 2450(10.5) | |  |
| Rangpur | | 76(2.7) | | 2689(97.3) | | 2765(11.8) | |  |
| Sylhet | | 74(3.7) | | 1942(96.3) | | 2016(8.6) | |  |
| **Women education level** | |  | |  | |  | |  |
| Primary or secondary | | 527(2.7) | | 19236(97.3) | | 19763(84.5) | | 0.001 |
| Higher secondary | | 60(1.6) | | 3579(98.4) | | 3639(15.6) | |  |
| **Birth order** | |  | |  | |  | |  |
| 1st parity | | 240(2.8) | | 8248(97.2) | | 8488(36.3) | |  |
| 2nd parity | | 264(2.2) | | 11944(97.8) | | 12208(52.2) | | 0.002 |
| 3rd parity or more | | 72(3.1) | | 2459(96.9) | | 2531(10.8) | |  |
| **Women age** | |  | |  | |  | |  |
| 15-19 | | 50(2.9) | | 1678(97.1) | | 1728(7.4) | |  |
| 20-24 | | 202(2.9) | | 6868(97.1) | | 7070(30.2) | | 0.055 |
| 25-29 | | 170(2.5) | | 6711(97.5) | | 6881(29.4) | |  |
| 30-34 | | 91(1.9) | | 4707(98.1) | | 4798(20.5) | |  |
| 35-39 | | 55(2.5) | | 2188(97.5) | | 2243(9.6) | |  |
| 40-44 | | 16(2.9) | | 535(97.1) | | 551(2.4) | |  |
| 45-49 | | 3(2.3) | | 128(97.7) | | 131(0.6) | |  |
| **Wealth index** | |  | |  | |  | |  |
| Poorest | | 306(2.9) | | 10355(97.1) | | 10661(45.6) | | <0.001 |
| Middle | | 214(2.4) | | 8613(97.6) | | 8827(37.7) | |  |
| Richest | | 67(1.7) | | 3847(98.3) | | 3914(16.7) | |  |
| **Total** | |  | |  | |  | |  |

**Table 2.** **Factor Associated with Neonatal Mortality**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Characteristics | **Crude IRR (95% CI)** | **p-value** | **Adjusted IRR (95% CI)** | **p-value** |
| **TT vaccinated** |  |  |  |  |
| Yes | 1 |  | 1 |  |
| No | 1.18(0.92,1.52) | 0.18 | 1.36(0.96,1.93) | 0.08 |
| **Cesarean section** |  |  |  |  |
| Yes | 1 |  | 1 |  |
| No | 1.48(1.04,2.10) | 0.03 | 1.32(0.93,1.88) | 0.12 |
| **Gender** |  |  |  |  |
| Boy | 1.23(1.02,1.47) | 0.03 | 1.27(0.92,1.75) | 0.15 |
| Girl | 1 |  | 1 |  |
| **ANC visits** |  |  |  |  |
| Less than 4 | 1 |  | 1 |  |
| Above 4 | 1.10(0.80,1.50) | 0.56 | 1.20(0.79,1.83) | 0.39 |
| Don’t know | 1.22(0.60,2.46) | 0.58 | 1.51(0.68,3.39) | 0.31 |
| **Division** |  |  |  |  |
| Barisal | 1.06(0.72,1.56) | 0.77 | 1.18(0.57,2.44) | 0.66 |
| Chittagong | 1.15(0.85,1.55) | 0.37 | 1.13(0.58,2.20) | 0.73 |
| Dhaka | 1 |  | 1.31(0.70,2.45) | 0.39 |
| Khulna | 1.13(0.78,1.63) | 0.53 | 1.05(0.54,2.05) | 0.88 |
| Mymensingh | 1.174(0.78,1.76) | 0.44 | 1.28(0.51,3.24) | 0.60 |
| Rajshahi | 1.355(0.97,1.89) | 0.08 | 1.25(0.63,2.49) | 0.53 |
| Rangpur | 1.31(0.93,1.85) | 0.12 | 1 |  |
| Sylhet | 1.90(1.29,2.78) | <0.01 | 1.66(0.65,4.25) | 0.290 |
| **Women education level** |  |  |  |  |
| Primary or secondary | 1.73(1.27,2.34) | <0.01 | 1.86(1.16,2.99) | 0.01 |
| Higher secondary | 1 |  | 1 |  |
| **Birth order** |  |  |  |  |
| 1st parity | 1.29(1.07,1.56) | <0.01 | 1.11(0.75,1.64) | 0.61 |
| 2nd parity | 1 |  | 1 |  |
| 3rd parity | 1.42(1.08,1.88) | 0.01 | 1.96(0.95,4.03) | 0.07 |
| **Women Age** |  |  |  |  |
| 15-19 | 1.61(1.09,2.37) | 0.01 | 1.36(0.60,3.09) | 0.46 |
| 20-24 | 1.68(1.25,2.27) | <0.01 | 1.89(0.93,3.86) | 0.08 |
| 25-29 | 1.50(1.11,2.02) | 0.01 | 1.62(0.86,3.04) | 0.13 |
| 30-34 | 1 |  | 1 |  |
| 35-39 | 1.34(0.90,1.99) | 0.14 | 1.09(0.46,2.54) | 0.85 |
| 40-44 | 1.76(0.95,3.25) | 0.07 | 2.35(0.44,12.45) | 0.32 |
| 45-49 | 1.95(0.63,6.05) | 0.25 | 4.05(0.97,16.95) | 0.06 |
| **Wealth index** |  |  |  |  |
| Poorest | 1.70(1.25,2.33) | 0.01 | 1.77(0.93,3.38) | 0.08 |
| Middle | 1.39(1.01,1.90) | 0.04 | 1.58(0.98,2.54) | 0.06 |
| Richest | 1 |  | 1 |  |

\* **IRR =**

**Appendix 1**  
Table 3: Analysis results for examining against Tetanus doses taken by mothers

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristics** | **Crude IRR (95% CI)** | **p-value** | **Adjusted IRR (95% CI)** | **p-value** |
| **TT doses taken** |  |  |  |  |
| None | 1 |  | 1 |  |
| 1 injection | 0.84(0.64,1.09) | 0.197 | 0.77(0.54,1.11) | 0.160 |
| 2 injections or more (adequate doses) | 0.87(0.57,1.32) | 0.498 | 0.54(0.29,1.01) | 0.054 |
| **Cesarean section** |  |  |  |  |
| Yes | 1 |  | 1 |  |
| No | 1.48(1.04,2.10) | 0.030 | 1.32(0.93,1.88) | 0.122 |
| **Gender** |  |  |  |  |
| Boy | 1.3(1.02,1.47) | 0.030 | 1.26(0.92,1.75) | 0.155 |
| Girl | 1 |  | 1 |  |
| **ANC visits** |  |  |  |  |
| Less than 4 | 1 |  | 1 |  |
| Above 4 | 1.01(0.80,1.51) | 0.560 | 1.20(0.77,1.83) | 0.401 |
| Don’t know | 1.22(0.61,2.46) | 0.580 | 1.51(0.67,3.38) | 0.320 |
| **Division** |  |  |  |  |
| Barisal | 1.06(0.72,1.56) | 0.770 | 1.18(0.57,2.44) | 0.663 |
| Chittagong | 1.15(0.85,1.56) | 0.370 | 1.14(0.58,2.22) | 0.709 |
| Dhaka | 1 |  | 1.32(0.71,2.46) | 0.388 |
| Khulna | 1.13(0.78,1.63) | 0.530 | 1.05(0.54,2.04) | 0.898 |
| Mymensingh | 1.17(0.78,1.76) | 0.440 | 1.28(0.51,3.24) | 0.603 |
| Rajshahi | 1.36(0.97,1.89) | 0.077 | 1.24(0.62,2.47) | 0.547 |
| Rangpur | 1.31(0.93,1.85) | 0.120 | 1 |  |
| Sylhet | 1.90(1.30,2.78) | <0.001 | 1.66(0.65,4.25) | 0.287 |
| **Women education level** |  |  |  |  |
| Primary or secondary | 1.73(1.27,2.34) | <0.001 | 1.86(1.15,2.98) | 0.011 |
| Higher secondary | 1 |  | 1 |  |
| **Birth order** |  |  |  |  |
| 1st parity | 1.29(1.07,1.55) | <0.001 | 1.10(0.75,1.64) | 0.617 |
| 2nd parity | 1 |  | 1 |  |
| 3rd parity | 1.42(1.08,1.88) | 0.010 | 1.96(0.95,4.02) | 0.068 |
| **Women Age** |  |  |  |  |
| 15-19 | 1.61(1.09,2.37) | 0.010 | 1.36(0.60,3.09) | 0.458 |
| 20-24 | 1.68(1.25,2.27) | <0.001 | 1.90(0.93,3.87) | 0.078 |
| 25-29 | 1.50(1.11,2.02) | 0.010 | 1.62(0.86,3.04) | 0.135 |
| 30-34 | 1 |  | 1 |  |
| 35-39 | 1.34(0.90,1.99) | 0.140 | 1.08(0.46,2.52) | 0.855 |
| 40-44 | 1.76(0.95,3.25) | 0.070 | 2.37(0.45,12.56) | 0.311 |
| 45-49 | 1.95(0.63,6.05) | 0.250 | 4.60(0.99,21.29) | 0.051 |
| **Wealth index** |  |  |  |  |
| Poorest | 1.71(1.25,2.33) | 0.010 | 1.78(0.94,3.40) | 0.079 |
| Middle | 1.39(1.01,1.90) | 0.040 | 1.59(0.99,2.56) | 0.054 |
| Richest | 1 |  | 1 |  |