Health Services Research and Managerial Epidemiology
Volume 4: 1-9

DOI: 10.1177/2333392817723970
journals.sagepub.com/home/hme
SAGE

Predictors of Neonatal Tetanus Mortality in Katsina State, Northwestern Nigeria

Shafique Sani Nass[1], Hadi Danawi[1], Loretta Cain[1], and Manoj Sharma[1]

Abstract

Background: The mortality rate of neonatal tetanus (NNT) remains high in Nigeria. The study was guided by Mosley and Chen's model for the elements of child survival in developing countries. The goal of the study was to assess the associations between selected NNT risk factors, number of maternal tetanus toxoid injections, frequency of antenatal visits, place of delivery, and cord care with neonatal mortality as the outcome variable.

Methods: The study is a retrospective record review using data from 332 NNT records and analyzed using a logistic regression model.

Findings: Neonates whose mothers had 1 dose of tetanus toxoid vaccine were found to be 4% less prone to NNT mortality compared to neonates whose mothers did not have any dose of tetanus toxoid vaccine during pregnancy ($P < .05$, odds ratio = 4.12, 95% confidence interval = 1.04-16.29. Frequency of antenatal visits, place of delivery, and cord care were all not significant predictors of NNT mortality.

Conclusion: The study shows that there is association between NNT risk factors and neonatal mortality, hence the need to further strengthen the NNT surveillance system for early detection of potential risk factors. This would help develop specific public health interventions aimed at improving the outcome of NNT.

Implications: The identification and analysis of NNT mortality risk factors and promoting tetanus toxoid vaccination among pregnant women are effective strategies toward attaining NNT elimination goals in Nigeria.

Keywords
neonatal tetanus, mortality, cord care, tetanus toxoid, antenatal care, place of delivery

Introduction

Recent studies have stressed the need for disease surveillance systems to have the capacity to detect events associated with diseases.[1] The Institute of Medicine recommended that new approaches in disease surveillance systems are required to strengthen rather than replace the existing ones.[2] Although the risk factors for developing neonatal tetanus (NNT) are well documented, the associations between the disease and neonatal mortality are still not well understood.[3] Of serious concern, little is known of the associations between NNT risk factors and NNT mortality,[3] which showed an important gap in the literature that requires further research. The outcome of this study can be used as evidence to strengthen the NNT surveillance system by looking at new approaches as well as introducing identification and analysis of NNT mortality risk factors. The data obtained can then be used to improve the quality and coverage of specific NNT public health interventions that will invariably reduce neonatal deaths.[4]

This study focused on 4 events associated with NNT that occur during antenatal, natal, or postnatal periods: the numbers of tetanus toxoid injections received by pregnant women, frequency of antenatal visits before delivery, place of delivery, and cord care.

Conceptual Framework

This study was guided by Mosley and Chen's (1984) framework for the study of child survival. The basic concept of the

[1] World Health Organization, Katsina State, Nigeria

Submitted May 18, 2017. Revised July 11, 2017. Accepted July 11, 2017.

Corresponding Author:
Shafique Sani Nass, World Health Organization, Murtala Mohammed Way, Katsina State Office, Katsina State, Nigeria.
Email: shafiquenass@yahoo.co.uk

framework is that child mortality occurs due to socioeconomic and cultural factors that operate through intermediate factors also known as proximate factors.[5] The framework was developed as a result of efforts by Mosley and Chen to integrate the roles of socioeconomic and cultural variables with the roles of disease processes in child health.[6] Examples of socioeconomic factors include parental marital and employment status, parental education, race, residence, beliefs, and so on. Proximate factors are those events that are closest to causing an outcome. The proximate factors selected for the study were number of tetanus toxoid injections received by mothers, frequency of antenatal visits attended by mothers, place of child delivery, and cord care provided to child after delivery. The choice of these variables was based on a literature gap regarding the associations between the selected proximate factors and neonatal death among newborns diagnosed with NNT in Nigeria and sub-Saharan Africa.

Tetanus Toxoid Vaccine

Tetanus toxoid vaccine is an inactivated vaccine that is administered to prevent tetanus infection in individuals. To reduce the global burden of NNT, the World Health Organization (WHO) introduced vaccination of tetanus toxoid to pregnant women in national immunization policies and strategies.[7] According to Blencowe et al,[8] deaths from NNT still remain endemic in Nigeria and India due to poor coverage of tetanus toxoid vaccines in rural communities. Death in neonates infected into tetanus often occurs due to prolonged periods of lack of oxygen supply to the brain (hypoxia) as a result of tetanus toxin-induced spasms and rigidity to the respiratory muscles.[9] An immunization coverage survey conducted in Nigeria showed that out of 601 mothers surveyed, only 25.2% of the mothers received the first dose of tetanus toxoid, while only 13.6% of the mothers received the second dose, and finally only 61.2% of the mothers received both first and second doses of tetanus toxoid.[10] Omotara et al[11] reported that immunization coverage of vaccine-preventable diseases in Northern Nigeria was lower than the south; however, there is limited evidence of contemporary literature on the actual coverage of tetanus toxoid among pregnant women in Northern Nigeria.

Antenatal Care

Antenatal care (ANC) is a systematic medical supervision of a pregnant woman by trained health personnel from conception up to the time of delivery. The WHO defines ANC as when a pregnant woman pays one or more visits to a qualified health worker during pregnancy.[12] The WHO and United Nations Children's Fund have recommended 4 visits as the minimum number of antenatal visits for each pregnancy from conception to delivery. Evidence from studies has indicated varying levels of utilization of ANC across sub-Saharan Africa.[13] Despite this, no attempt was made by the researchers to identify the association between the levels of utilization of ANC services and neonatal mortality. Tetanus toxoid immunization is the vital component of ANC that determines NNT mortality rate in a community. If the tetanus toxoid coverage is high during ANC, then newborns are less likely to get infected with NNT. However, there is little empirical evidence on the missed opportunities for immunization against NNT among pregnant woman during ANC visits and its association with neonatal mortality in developing countries.[14] Nevertheless, Babatunde et al[15] conducted a 5-year review (2007-2012) of 1130 clinical case notes in a tertiary health center in Southwest Nigeria. The researchers found only 6 clinically diagnosed NNT cases out of the 1130 cases in the hospital within the 5-year period. The results showed that 4 (66.7%) of the NNT cases had mothers who did not attend ANC during pregnancy. The researchers however did not attempt to assess any association between the lack of antenatal visits and NNT mortality rate during the 5-year period.

Place of Delivery

The place of delivery is an important factor in the prevention of both maternal and neonatal mortalities. Place of birth could be at home or in the health facility. Home births occur when a baby is delivered at the mother's place of residence.[16] By definition, skilled birth attendants are accredited health workers that include physicians, nurses, or midwives who are trained in the skills required to attend to or manage pregnancies that are uncomplicated, normal deliveries and during the postnatal period, and also identify, manage, and refer complications in mothers and newborns.[17] Traditional birth attendants (TBAs) are unskilled workers, thus are not included in the definition of skilled birth attendants. Pregnant women who deliver at home are often attended by TBAs in developing countries.[18] The proportion of births attended by skilled birth attendants is vital in reducing neonatal mortality. Skilled birth attendants reduce neonatal deaths through safe and hygienic delivery practices to avoid NNT infection. They often use sterilized instruments to cut and clean the umbilical cord during and after delivery, respectively. Some common unhygienic delivery habits practiced by unskilled birth attendants that predisposed neonates to tetanus infection include treatment of umbilical cord with soil or cow feces which is likely to be contaminated with *Clostridium tetani*, the causative agent of NNT,[19] and unclean/unsterilized razor blades.[20] Lawoyin et al[21] in a study conducted in southern Nigeria reported a significant association between mothers who delivered outside health facilities and neonatal death, but not NNT mortality rate. On the contrary, Fetuga et al[22] reviewed 151 NNT death cases from 1991 to 2005 in a tertiary hospital in Southern Nigeria using logistic regression model and reported a significant association between delivery outside health facilities (89.6%) and NNT mortality rate.

Cord Care

Cord care is a specialized care to the umbilical cord of a newborn commenced from delivery up to the time it falls off to

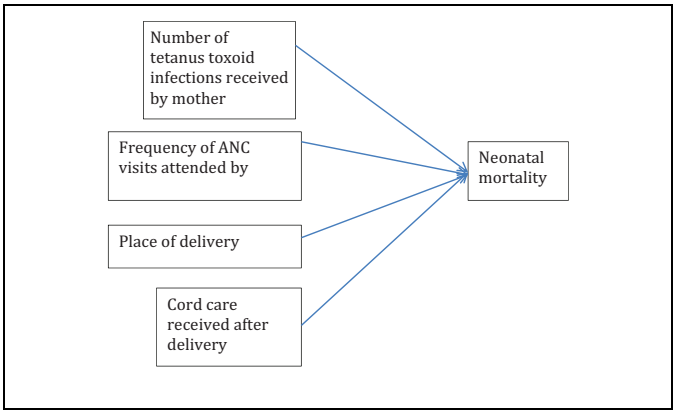

Figure 1. Model of hypothesized association between 5 constructs in the study. ANC indicates antenatal care.

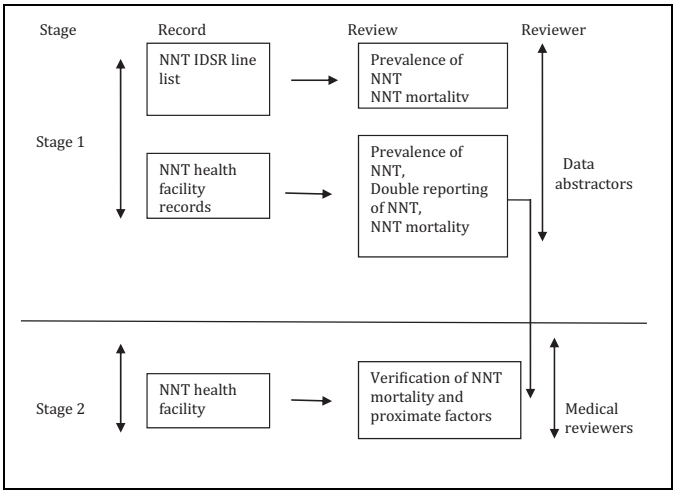

Figure 2. Active surveillance retrospective record review process used in the study. At the first stage of the review process, data abstractors extract information on the prevalence of NNT and NNT mortality from the IDSR database of each health facility. Secondly, the data extractors will also screen for information on the prevalence of NNT, NNT mortality, and double reporting of NNT from health facility records and IDSR line list. The second stage of the review process is the verification of positively screened data by medical reviewers. The medical reviewers will verify information on NNT mortality and proximate factors. Adapted from Zegers et al.[31] Reproduced with permission. NNT indicates neonatal tetanus.

prevent the transmission of infection. Studies have shown that about 25% of global neonatal deaths were attributed to poor cord care which leads to umbilical cord infections including NNT.[23] Umbilical cord infections are collectively referred to as omphalitis. The incidence of omphalitis in Turkey was as high as 77 per 1000 live births[24] and 217 per 1000 in Pakistan.[25] Poor cord care practices can cause omphalitis, such as cleansing the umbilical cord with contaminated substances, which is a usual practice by unskilled attendants at home delivery, and local sterilization of the umbilical stump using direct thermal heat, which destroys the umbilical cord tissue leading to bacterial infection including NNT.[26] Unskilled birth attendants in some parts of Southern Nigeria were found to be cleansing the umbilical cord with herbal preparations, cow dung, ash, coconut oil, or mud. However, little is known in the literature on the incidence of NNT due to poor cord care practices and its association with neonatal death in Nigeria. In 2014, the WHO recommended the use of 4% chlorhexidine for cleaning the umbilical cord stump for the first 7 days of life for newborns delivered at home in countries with neonatal mortality rate equal to or more than 30 deaths per 1000 live births. However, the application of any form of antiseptic to the umbilical cord stump after birth is not recommended for newborns delivered both at home and in health facilities in countries with less than 30 neonatal deaths per 1000 live births.[27]

Methods

The study was a cross-sectional survey of NNT Integrated Disease Surveillance and Response (IDSR) surveillance data and health facility retrospective record review from January 1, 2010, to December 31, 2014. A cross-sectional approach was utilized in this study because it provides a rapid assessment of the prevalence of a disease in a target population.[28] Cross-sectional surveys are also used to examine the associations between risk factors and variables of interest. Information was extracted by trained nurses as data abstractors and experienced physicians as medical reviewers from the 3 geopolitical zones (constituencies) of Katsina State, Nigeria. Access to both NNT IDSR data and health facility records was gained with the permission of Katsina State Ministry of Health. The NNT IDSR data included NNT cases confirmed based on the WHO case definition of NNT as any newborn who could suckle normally in the first 2 days of life but was unable to suckle between the 3rd and 28th days and has muscles spams or becomes stiff during the period of illness.[29] The data abstractors also screened for double reporting of NNT cases in both IDSR and health facility records. Double reporting occurs when an NNT case is counted twice before the final prevalence rate was calculated.

The study aimed to identify whether or not associations existed between proximate factors and neonatal death using a binary logistic regression model. Data were analyzed using SPSS version 24. The proximate factors represented the independent variables, namely: (a) number of tetanus toxoid injections received by mothers, (b) the frequency of ANC visits attended by mothers, (c) place of delivery, and (d) cord care provided after delivery. Neonatal mortality represented the dependent variable, which was defined as death of newborn within the first 28 days of life.[29] Both independent and dependent variables were extracted from retrospective record review of NNT health facility records. Figure 1 depicts the association between the 5 constructs.

Retrospective record review of health facilities was considered as the appropriate approach for this study because it could determine the prevalence and risk factors for health events.[30] Figure 2 depicts the retrospective review process in the study.

Due to limited time and resources, multistage sampling technique was utilized to draw samples from each level of

health care, that is, primary, secondary, and tertiary, in each of the 3 geopolitical zones in the state. The study sample consisted of 332 records of mothers of patients with NNT that were predetermined by 3 steps: (1) setting precision and statistical power, (2) calculating effective sample size using power analysis, and (3) sample size adjustment using design effect.[32]

In the first step, the level of precision or α level was set at .05 so as to have a 5% chance of rejecting type I error. The statistical power was set at 95% to show that, with the sample size, the study can expect mean association between the proximate factors and neonatal death in 95% of the time. In the second step, effective sample size of 166 was realized following power analysis. However, the effective sample size was adjusted so as to account for the variance caused by multistage sampling technique. To adjust for deviation from simple random sampling, the effective sample size was multiplied by the design effect (DEFF).[33] In this study, the design effect was determined from a previous tetanus survey by Orimadegun et al,[34] who used a design effect factor of 2 to estimate the sample size required for a tetanus prevalence survey in Nigeria. Thus, sample size (N) = effective sample size $\times$ design effect (DEFF), which is 332.

Sampling and Sampling Procedure

The study population comprised mothers of newborns affected with NNT in Katsina State, Nigeria. The sample size for this study was realized through multistaged sampling technique so as to obtain a representative sample of participants from each of the 3 zones in the state. The multistage sampling technique was conducted in 3 stages that include: (1) Selection of local government areas (LGAs) through random sampling and the LGAs selected were Katsina LGA, Malumfashi LGA, and Daura LGA from Katsina, Funtua, and Daura zones, respectively. (2) Selection of health facilities from the 3 levels of health delivery, that is, tertiary, secondary, and primary levels. The health facilities were sampled using random number of tables and those selected include General Hospital, Malumfashi (secondary) and Primary Health Center, Malumfashi (primary) in Malumfashi LGA; General Hospital, Daura (secondary) and Primary Health Centre, Dan Nakola (primary) in Daura LGA; and Federal Medical Center, Katsina (tertiary), General Hospital, Katsina (secondary), and Primary Health Center, Kofar Guga (primary) in Katsina LGA. (3) The 332 records of the study population were selected through proportional probability sampling (PPS) technique due to the variations in the amount of patients with NNT admitted in the health centers, as depicted in Figure 3.

An estimated 30 randomly selected NNT cases were tested in the pilot study at General Hospital, Dutsin-Ma, Katsina zone, Katsina State; these selected NNT cases were not be included in the larger study. It was conducted to assess the reliability and validity of instruments of data collection and to avoid missing data which is major challenge in retrospective record reviews.[30] The pilot study also enables the data abstractors to be more aware of inclusion and exclusion criteria and identification of certain challenges with the use of survey instruments. The

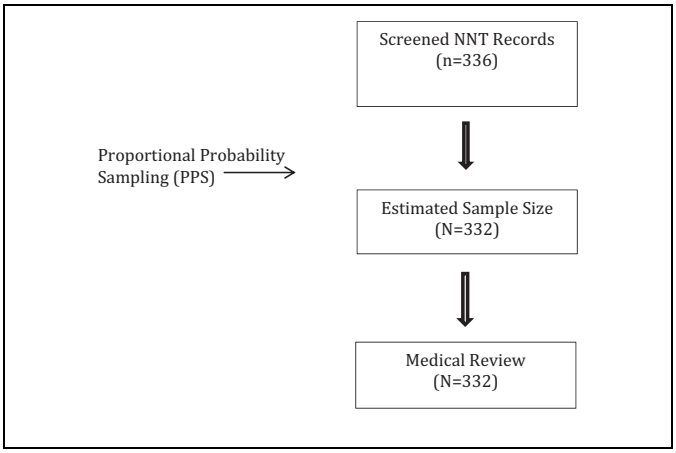

Figure 3. Participant flowchart. The NNT records reviewed for the study were selected from the positively screened records using proportional probability sampling. NNT indicates neonatal tetanus.

inclusion criteria were: (1) only infants born within the neonatal period, that is, first 28 days of life; (2) all cases that had met the WHO case definition NNT; (3) all NNT cases treated in health facilities; and (4) all NNT cases treated from January 01, 2010, to December 31, 2015. The exclusion criteria were: (1) all infants born outside the neonatal period, that is, above 28 days old; (2) all cases that have not met the WHO criteria for NNT; (3) all NNT cases treated at home; and (4) all NNT cases treated prior to January 01, 2010, or after December 31, 2014.

Instrumentation and Operationalization of Constructs

Forms A, B, and C were the instruments of data collection for the study. Form A was used to extract NNT prevalence and mortality data from the IDSR database in the 7 selected health facilities in Katsina State. The form was adapted from the WHO Death Investigation Form developed in 2002.[29] The format of the form was modified for the abstraction of NNT prevalence and mortality rates in this study. The original instrument was used by Cotter et al[35] for the evaluation of NNT elimination in Zimbabwe. Permission to modify and utilize the instrument for this study was sought from the Department of Vaccines and Biologicals, WHO, Geneva, Switzerland. Forms B and C were utilized by data abstractors and medical reviewers, respectively. Both forms are modified versions of RF1 and RF2 developed by the WHO Patient Safety Working Group for the review of harmful incidents in resource poor settings.[35] The forms are appropriate specifically for retrospective record reviews and were used in 2005 by the WHO for the retrospective review of harmful incidences among 18 146 randomly selected patients in 5 African countries, namely, Egypt, Kenya, South Africa, Sudan, and Tunisia.[36]

Data Analysis

This study examined the associations between the number of tetanus toxoid injections, frequency of ANC visits, place of

Table 1. Outcome of the Collinearity Diagnostics of the Independent Variables.

	Collinearity Statistics	
Independent variable	Tolerance	VIF
Number of tetanus toxoid injection	0.331	3.021
Frequency of antenatal visits	0.305	3.275
Place of delivery	0.609	1.642
Cord care after delivery	0.635	1.574

Abbreviation: VIF, variance inflation factor.

delivery, and cord with NNT mortality using bivariate logistic regression model including adjusted odds ratios (ORs) and related 95% confidence intervals (95% CIs).

Results

The results of the pilot study indicated uniformity and consistency of data entry (interrater reliability) among 2 data abstractors and 2 medical reviewers (Cohen κ for data abstractors = 0.710, $P < .0001$, 95% CI: 0.41-1.01; Cohen κ for medical reviewers = 0.760, $P < .0001$, 95% CI: 0.44-1.06)

A total of 336 NNT cases were identified in the 7 health facilities sampled in the study area. Since the estimated sample size for the study was 332, the selection of study participants (NNT records) was based on PPS technique due to variations in the amount of NNT cases admitted in the health centers. Consequently, there were no significant challenges faced during the retrospective record review process and no alterations in the retrospective review protocol described. The parametric assumptions for analyzing data for the study using logistic regression were checked prior to analysis. These 4 assumptions were all met, which were: assumption 1, the dependent variable (neonatal mortality) was a dichotomous variable, that is, "survived" and "death"; assumption 2, the independent variables were all categorical variables; assumption 3, there was independence of observations and the outcome variable had exhaustive and mutually exclusive categories; and assumption 4, there was no high correlation (multicollinearity) between the independent variables. Table 1 shows the outcome of the collinearity diagnostics indicating the independent variables; number of tetanus toxoid injection, tolerance = 0.331; variance inflation factor (VIF) = 3.021, frequency of antenatal visits, tolerance = 0.305; VIF = 3.275, place of delivery, tolerance = 0.609, VIF = 1.642; cord care, tolerance = 0.635, VIF = 1.574. Because all tolerance values were greater than 0.1 and all VIF values were less than 5, then multicollinearity was not a concern.

The relationship between the proximate factors and outcome of NNT is depicted in Table 2. Concerning the number of tetanus toxoid vaccines received, up to 59% (n = 197) neonates died whose mothers did not receive a single dose of NNT vaccine, while only 6% (n = 19) of neonates died whose mothers received more than 2 doses of NNT vaccine ($\chi^2 = 7.80$, $df = 2$, $P = .02$). Concerning the frequency of ANC visits, about

Table 2. Relationship Between the Proximate Factors and the Outcome of Neonatal Tetanus.

	Outcome				
Proximate Factors	Survived (%)	Death (%)	χ^2	*P*	*df*
NTT					
None	57 (17)	197 (59)			
1	13 (4)	31 (9)	7.80	.02	2
2 or more	15 (5)	19 (6)			
FAV					
No visit	54 (16.3)	177 (53)			
1 to 3 visits	20 (6.3)	54 (16.3)	3.93	.14	2
4 visits	11 (3)	16 (5)			
POD					
Home	65 (19.6)	225 (67.8)	12.24	.00	1
Health center	20 (6.3)	22 (6.6)			
CC					
Septic treatment	58 (17.5)	212 (63.8)	12.90	.00	1
Aseptic treatment	27 (8.1)	35 (10.5)			

Abbreviations: CC, cord care; FAV, frequency of antenatal visits; NTT, number of neonatal tetanus injection; POD, place of delivery.

53% (n = 177) of neonates died whose mothers did not pay single ANC visit during pregnancy, while 16.3% (n = 54) of neonates died whose mothers had 1 to 3 visits of ANC visits during pregnancy, and 5% (n = 16) died whose mothers completed the 4 ANC visits during pregnancy ($\chi^2 = 3.93$, $df = 2$, $P = .14$). Concerning the place of delivery, up to 67.8% (n = 725) of neonates delivered at home died of NNT ($\chi^2 = 12.24$, $df = 1$, $P < .00$). A great majority of neonates (63.8%, n = 212) who received septic cord care treatment after delivery died of NNT ($\chi^2 = 12.90$, $df = 1$, $P < .00$).

A binary logistic regression analysis was conducted to predict NNT mortality based upon certain proximate factors, namely, number of tetanus toxoid injections, frequency of antenatal visits, place of delivery, and cord care. Preliminary analysis was conducted to ensure that the logistic regression model does fit the data (Hosmer and Lemeshow $\chi^2 = 4.94$, $P > .05$), and there was no violation of the assumption of multicollinearity. The logistic combination of the proximate factors was found to be significantly associated with NNT mortality, $\chi^2 = 19.68$, $P < .05$ with $df = 6$. The logistic regression model indicated 9% (Nagelkerke $R^2 = .09$) of the variance in NNT mortality, and the overall prediction success of cases was 75%. The Wald criterion indicated that only neonates whose mothers had 1 dose of NNT vaccine were significantly associated with NNT mortality. However, the findings of research questions 2, 3, and 4 showed no significant associations between frequency of ANC visits ($P = .20$), place of delivery ($P = .09$), and cord care ($P = .10$), respectively. The Exp (B) value demonstrates that neonates whose mothers had 1 dose of tetanus toxoid vaccine were found to be 4% less prone to NNT mortality compared to neonates whose mothers did not have any dose of tetanus toxoid vaccine during pregnancy ($P < .05$, OR = 4.12, 95% CI = 1.04-16.29). Table 3 shows the summary of binary

Table 3. Summary of Binary Logistic Regression Analysis for Proximate Factors Predicting the Outcome of Neonatal Tetanus for Neonates.[a]

Proximate Factors	β	SE β	Wald χ^2	*P*	e^B	95% CI	
						Upper	Lower
Constant	0.98	0.47	4.37	.04	2.67		
Number of NNT injections							
None					1.0		
1	1.42	0.70	4.08	.04	4.12	1.04	16.29
2 or more	0.68	0.68	0.10	.32	1. 98	0.52	7.57
Frequency of ANC visits							
No visit					1.0		
1 to 3 visits	−1.06	0.82	1.65	.20	0.35	0.07	1.74
4 visits	−0.36	0.72	0.25	.62	0.70	0.17	2.90
Place of delivery							
At home					1.0		
In a health facility	−0.77	0.46	2.83	.09	0.46	0.19	1.14
Cord care							
Septic treatment					1.0		
Aseptic treatment	−0.65	0.39	2.77	.10	0.53	0.25	1.12
Model χ^2		19.68		.03	[b]		
Hosmer and Lemeshow		4.94		.29			
Nagelkerke R^2		0.09					

Abbreviations: ANC, antenatal care; CI, confidence interval; NNT, neonatal tetanus; SE, standard error.
[a]N = 332.
[b]$P < .05$.

logistic regression analysis for proximate factors predicting the outcome of NNT.

Discussions

Findings from inferential statistics showed significant association between neonates whose mothers had only 1 dose of NNT vaccine and NNT mortality ($P = .04$, OR = 4.12, 95% CI = 1.04-16.29). Mothers who had 1 dose of tetanus toxoid vaccine were found to be 4% less prone to NNT mortality compared to neonates whose mothers did not have any dose of tetanus toxoid vaccine during pregnancy. The findings correlate with an NNT survey by Akinyemi et al,[37] which used Cox hazard's model that reported that tetanus toxoid injection was associated with a decrease in neonatal mortality rate (hazard ratio = 0.82, 95% CI = 0.64-1.05). Similarly, McCurdy et al[38] found that newborns whose mothers received 2 or more tetanus toxoid injections were associated with low neonatal mortality rate (OR = 0.78, $P < .001$).

Limitations of the Study

The limitation that relates to threat to internal validity was confirmed in this study. There were some concerns regarding the quality of record keeping faced in primary health centers in the rural communities. Because these challenges were not pronounced during the pilot survey, they were not anticipated in the main study. The reason was probably due to the fact that the health facility where the pilot survey was conducted (General Hospital, Dutsin-Ma) was a secondary health facility located in an urban setting that had a more functional records department with better skilled personnel than the primary health facilities in rural areas.

Recommendations

Evidence from this study suggests that the number of NNT injections is associated with neonatal mortality; thus, it is imperative to promote tetanus toxoid vaccination in the community as a means of preventing NNT mortality. The target groups for this health promotion are pregnant mothers, TBAs, and community leaders or influencers in Katsina State, Nigeria. Although TBAs are not considered as skilled health personnel, their role and influence in reducing neonatal mortality through health promotion in developing countries is acknowledged.[39,40] Similarly, community leaders have been found to be effective in reducing child mortality through effective communication skills and motivation in developing countries.[41,42] The focus of health promotion should be on the relevance of receiving and completing the 5 doses of tetanus toxoid injections during ANC. Due to the low literacy rate particularly among the mainstream population in Northern Nigeria,[31] mode of communication will be through the use of visual aids like pictograms for better understanding. The outcome of this study is particularly useful to Diseases Surveillance and Notification Officers and directors of the public health surveillance systems in Nigeria so as to strengthen and expand NNT surveillance by integrating NNT risk factors surveillance with the IDSR system.

Missing data was an important challenge faced during the data collection process. In the future studies, pilot surveys involving retrospective record surveys should be conducted in less equipped health facilities so as to identify and find ways

of addressing missing data before commencing the main study. Missing data can also minimized by the structuring and standardizing the questionnaires using closed-ended questions. This study was focused primarily on the impact of maternal proximate factors on NNT mortality; there is a need to conduct studies to identify the impact of community, social, and economic factors, for example, distance to health facility, parents' education, and religious beliefs on NNT mortality. Furthermore, future research should be conducted in the communities; findings from such community surveys may provide an in-depth assessment of the associations between risk factors and NNT mortality including the risk factors found not significantly associated with NNT mortality in this study. Although several studies concerning risk factors of NNT have been conducted, however, contemporary literate has shown that only few studies were conducted that focused on the associations of proximate factors and NNT mortality. This study indicates 2 important findings: significant association between the number of tetanus toxoid injections received by mothers and NNT mortality and underreporting of NNT in Katsina State, Nigeria. Based on these findings, methodological implications for future research includes conducting a face-to-face community survey which may provide better insight in identifying the associations between socioeconomic risk factors and NNT mortality.

Conclusion

It is imperative to adopt a novel surveillance approach by introducing identification and analysis of NNT mortality risk factors and promote tetanus toxoid vaccination among pregnant women in order to reduce the burden of the disease and attain elimination goals.

Acknowledgments

The authors acknowledge, with gratitude, approval for the use of the NNT data set from the Ministry of Health of Katsina State, Nigeria for the sole purpose of this study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

1. Choi BC. The past, present, and future of public health. *Scientifica (Cairo)*. 2012;2012:875253. doi:10.6064/2012/875253h.
2. May L, Chretien J, Paulin JA. Beyond traditional surveillance: applying syndromic surveillance to developing settings-opportunities and challenges. *BMC Public Health*. 2009;9:242. doi:10.1186/1471-2458-9-242.
3. Lambo JA, Anokye EA. Prognostic factors for mortality in neonatal tetanus: a systematic review and meta-analysis. *Int J Infect Dis*. 2013;17(12):e1100-e1110.
4. Lawn JE, Beber K, Enweronu-Laryea C, Cousens S. 3.6 million neonatal deaths: what is progressing and what is not. *Semin Perinatol*. 2010;34(6);371-386.
5. Lasen M, Carmichael G. *Demography of the Kronadal B'la-an: A Comparative Study of Child Survival in the Tampakan Highlands, Southern Philippines*. Saarbrucken, Germany: Aktiengesellschaft and Company; 2010.
6. Macassa G, Hallqvist J, Lynch JW. Inequalities in child mortality in sub-Saharan Africa: a social epidemiologic framework. *African J Health Sci*. 2011;18: 14-16. www.ajhsjournal.or.ke/admin/current/b1En2PBSrhj.pdf. Accessed August 11, 2016. Updated April 21, 2017.
7. Singh A, Komar A, Kumar A. Determinants of neonatal mortality in rural India, 2007-2008. *PeerJ*. 2013;1:e75. doi:10.7717/peerj.75.
8. Blencowe H, Lawn J, Vandelaer J, Roper M, Cousens S. Tetanus toxoid immunization to reduce mortality from neonatal tetanus. *Int J Epidemiol*. 2010;39(suppl 1):i102-i109. www.ncbi.nlm.nih.gov/pmc/articles/pmc2845866/. Accessed August 15, 2016. Updated April 22, 2017.
9. Hassel B. Tetanus pathophysiology, treatment, and the possibility of using Botulism toxin against tetanus-induced rigidity and spasms. *Toxins(Basel)*. 2013;5(1):73-83. doi:10.3390/toxins5010073.
10. Kunle-Olowu A, Kunle-Olowu OE, Emeka UM. Immunization coverage of antenatal and immunization clinics attendance in the Niger Delta University Teaching Hospital. *J Public Health Epidemiol*. 2010;3(3):90-93.
11. Omotara BA, Okujagu TF, Etatuvie SO, Beida O, Gbodossou E. Assessment of knowledge, attitude and practice of stakeholders towards immunization in Borno state, Nigeria: a qualitative approach. *J Commun Med Health Educ*. 2012;2(9). doi:10.4172/216-0711.1000181.
12. Adeoye KR, Musa IO, Atoyesi OA, Babatunde OA. Knowledge and utilization of anti-natal care services by women of child bearing age in Ilorin-East local government area, North Central Nigeria. *Int J Sci Technol*. 2013;3(3):188-193.
13. Pell C, Meñeca A, Were F, et al. Factors affecting antenatal care attendance: results from qualitative studies in Ghana, Kenya and Malawi. *Plos One.* 2013;8(1):e53747. doi:10.1371/journal.pone.0053747.
14. Lassi ZS, Mansoor T, Salam RA, Das JK, Bhutta ZA. Essential pre-pregnancy and pregnancy interventions for improved maternal, newborn and child health. *Reprod Health*. 2014;11(suppl 1):S2. www.reproductive_health_journal.com/content/11/51/52. Accessed August 19, 2016. Updated April 23, 2017.
15. Babatunde OA, Adebara VO, Atoyebi OA, Oluwagbemi OA. Neonatal tetanus in Federal Medical Center, Ido-Ekiti South West Nigeria in a five year retrospective study. *Greener J Med Sci*. 2014;4(2):42-47.
16. Dekker R. *What is Home Birth? Evidence Based Birth*. 2012; http://evidencebasedbirth.com/what-is-home-birth/. Accessed August 28, 2016. Updated April 25, 2017.
17. Utz B, Siddique B, Adegoke A, van den Broek N. Definitions and roles of skilled birth attendant: a mapping exercise from four south-Asian countries. *Acta Obstet Gynecol Scand*. 2013;92(9):1063-1069.
18. Wilson A, Gallos ID, Plana N, et al. Effectiveness of strategies incorporating training and support of traditional birth attendants

on perinatal and maternal mortality: meta-analysis. *BMJ*. 2011; 343:d7102. doi:101136/bmj.d7102.
19. Emeribe VC, Akah LU. Neonatal tetanus in African Children's causes, symptoms, predisposing factors, prevention and control. *Arts Soc Sci J*. 2011; www.astonjournal.com/manuscripts/vol2011/ASSJ_23_Vol2011.pdf. Accessed September 09, 2016. Updated April 28, 2017.
20. Babu G, Ramachandra S, Garikipati U, Mahpatra T, Narayana S, Pant H. Maternal correlates of neonatal deaths in tribal area in India. *Internet J Epidemiol*. 2012;10(2):1-10.
21. Lawoyin TO, Onadeko MO, Asekun-Olarinmoye EO. Neonatal mortality and perinatal risk factors in rural Southwestern Nigeria: a community-based prospective study. *West Afr J Med*. 2010; 29(1):19-23.
22. Fetuga BM, Ogunlesi TA, Adekambi FA. Risk factors for mortality in neonatal tetanus: a 15 year experience in Sagamu, Nigeria. *World J Pediatr*. 2010;6(1):71-75. doi:10.1007/s12519-010-0010-9.
23. Opara PI, Jaja T, Okari TG. Newborn cord care practices amongst mothers in Port Harcourt, Nigeria. *Jos J Med*. 2013;6(3):22-27.
24. Vanisree R, Lata KM, Neelima A. Umbilical cord infections in neonates with special reference to MRSA. *World J Pharm Pharm Sci*. 2014;3(7):724-731.
25. Mir F, Tikmani SS, Shakoor S, et al. Incidence and etiology of omphalitis in Pakistan: a community-based cohort study. *J Infect Dis Dev Countries*. 2013;5(12):828-833.
26. Joel-Medewase VI, Adegoke AA, Oyedeji OA. Omphalitis in a Nigerian neonates: lessons to learn. *Int J Trop Dis Health*. 2014; 4(7):760-765.
27. World Health Organization. *WHO Recommendations on Postnatal Care of the Mother and New Born*. 2013. www.who.int/iris/bitstram/10665/976003/1/9789241506649_eng.pdf. Accessed September 13, 2016. Updated May 01, 2017.
28. Olsen C, St. George DM. *Cross-sectional Study Design and Data Analysis. College Entrance Examination Board*. 2004. www.collegeboard.com/prod_downloads/yes/4297_MODULE_05.pdf. Accessed September 21, 2016. Updated May 02, 2017.
29. World Health Organization. *Humanitarian Health Action: Definitions*. 2015. www.who.int/hac/about/definitions/en. Accessed September 22, 2016. Updated May 02, 2017.
30. Vassar M, Holzmann M. The retrospective chart review: important methodological considerations. *J Educ Eval Health Prof*. 2013;10:12. doi:10.3352/jeehp.2013.10.12.
31. Zegers M, de Bruijine MC, Wagner C, Groenewegen PP, Waaijiman R, van der Wal G. Design of a retrospective patient record study on the occurrences of adverse events among patients in Dutch hospitals. *BMC Health Serv Res*. 2007;7:27. doi:10.1186/1472-6963-7-27.
32. Israel GD. *Determining Sample Size.* University of Florida IFAS Extension website. 2009. https://edis.ifas.ufl.edu/pdffiles/PD/PD00600.pdf. Accessed September 23 2016. Updated May 03 2017.
33. Salganik MJ. Variance estimation, design effects, and sample size calculations for respond-driven sampling. *J Urban Health*. 2006; 83(7). doi:10.1007/s11524-006-9106-x. Accessed October 02, 2016. Updated May 04, 2017.
34. Orimadegun AE, Adepoju AA, Akinyinka OO. Prevalence and socio-demographic factors associated with non-protective immunity against tetanus among high school adolescent girls in Nigeria. *Italian J Pediatr*. 2014;40(1). www.ijponline.net/content/40/1/29.
35. Cotter B, Bremer V, Stroth G, et al. Assessment of neonatal tetanus elimination in African setting by lot quality assurance cluster sampling (LQA-CS). *Epidemiol Infect*. 2003;130(2): 221-226. doi:10.1017/50950268802008233.
36. World Health Organization. *Assessing and Tackling Patient Harm: A Methodological Guide for Data-poor Hospitals*. 2010. www.int/patientsafety/research/methodological_guide/method1_protocol.pdf. Accessed October 05, 2016. Updated May 05, 2017.
37. Akinyemi JO, Bamgboye EA, Ayeni O. New trends in under-five mortality determinants and their effects on child survival in Nigeria: a review of childhood mortality data from 1990-2008. *Afr Popul Stud*. 2013;27(1):25-42.
38. McCurdy RJ, Kjerulff KH, Zhu J. Prenatal care associated with reduction of neonatal mortality in sub-Saharan Africa: evidence from demographic and health surveys. *Nordic Federation Soc Obstet Gynecol*. 2011;90:779-790. doi: 10.1111/j.1600 0412. 2011.01133.x
39. Falle TY, Mullany LC, Thatte N, et al. Potential role of traditional birth attendants in neonatal healthcare in rural communities. *J Public Health Nutr*. 2009;27:53-61.
40. Pyone T, Adaji S, Madaj B, Woldetsadik T, van den Broek N. Changing the role of the traditional birth attendant in Somaliland. *Int J Gynecol Obstet*. 2014;127(1): 41-46. doi: 10.1016/j.ijgo. 2014.04.009.
41. Glanz K, Rimer B K, Viswanath K. *Health Behavior and Health Education: Theory, Research, and Practice*. 4th ed. Jossey-Bass; 2008.
42. Kulbok PA, Thatcher E, Park E, Meszaros PS. Evolving public health nursing roles: focus on community participatory health promotion and prevention. *Online J Issues Nurs*. 2012;17(2). doi:10.3912/OJIN.Vol17No02Man01.

Author Biographies

Shafique Sani Nass is a Global Health Physician and an Epidemiologist. He received his PhD in Public Health from Walden University, Minneapolis, Minnesota, USA and a Master of Public Health degree from Usman Danfodio University, Sokoto, Nigeria. He trained as a medical doctor with the MBBS degree from Bayero University, Kano, Nigeria. Dr Nass is a member of the American College of Epidemiology and has vast experience serving in both local and international public health programs. His research interests lie in the area of infectious diseases, child health and neglected tropical diseases. He currently serves as a monitoring and evaluation officer with the World Health Organization (Immunizations, Vaccines and Emergencies Cluster) in Nigeria.

Hadi Danawi trained in Public Health with a PhD in Epidemiology from the University of Texas at Houston and a master degree in Environmental Health from the American University of Beirut, Dr. Danawi has an international exposure to various Public Health issues in the U.S. Middle East and Africa. Dr. Danawi is passionate about creating positive social change and truly believes his research interests should be multidisciplinary as is Public Health. Dr. Danawi currently serves as a full time faculty at Walden University, College of Health Sciences teaching and mentoring doctoral dissertations.

Loretta Cain is a biostatistician and epidemiologist at the University of Mississippi Medical Center where most of her research involves risk factors and outcomes of cardiovascular health in African Americans in Jackson, MS (The Jackson Heart Study). Additionally, she serves as a dissertation chair and committee member for doctoral students at Walden University.

Manoj Sharma is a public health physician having completed his doctorate in Preventive Medicine from The Ohio State University. He serves as a tenured Professor in Behavioral and Environmental Health at Jackson State University and as University Research Reviewer at Walden University. His interests are in health behavior research, obesity and mind body-interventions.