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Risk Factors of Neonatal Tetanus in Senegal

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A case-control study for evaluating the risk factors of neonatal tetanus was conducted in a rural area of Senegal under demographic surveillance (Niakhar). Some 45 neonatal tetanus deaths that occurred in the study area between March 1983 and March 1986 were investigated. They were matched with 187 controls. Neonatal tetanus accounted for one-third of all neonatal deaths; mortality from neonatal tetanus was 16/1000 livebirths. The effect of various demographic, socioeconomic, epidemiological and behavioural factors was investigated in a multivariate analysis using linear logistic regression.

There was no difference associated with socioeconomic factors between cases and controls. Factors associated with the skill and behaviour of birth attendant and mother were highly significant and were associated with high odds ratio (OR) and included whether the hands of the person cutting the cord were washed with soap (OR = 5.22; p = 0.001); whether the person who dressed the cord was skilled (OR = 4.71; p = 0.012); whether the age of the mother was less than 18 years (OR = 7.03; p =0.027) and whether the birth attendant arrived before delivery (OR = 4.15, p = 0.023). Conversely, the type of tool used to cut the cord did not have a significant effect (p = 0.239). Data analysis suggests that a main source of *Clostridium tetani* may be the hands of the birth attendant and that the main mode of contamination may be the dressing of the wound stump. Results suggest that teaching mothers and birth attendants simple hygienic principles and basic techniques may have a significant impact on neonatal tetanus mortality.

Neonatal tetanus remains one of the major causes of death in developing countries.[1,2] Neonatal tetanus has a high mortality rate. Once a newborn develops the first symptoms of tetanus during the first four weeks of life he or she usually dies within a few days, except when intensive care can be given on time, which is rarely possible in developing countries. Little is known about the exact mode of contamination leading to neonatal tetanus. The tetanus germ (*Clostridium tetani*) is ubiquitous and there are various ways through which it can enter the umbilical cord of a neonate: through direct contact with soil at the time of delivery, through cutting or binding the umbilical cord or through the various ointments or clothes put on the umbilical wound. A recent study from Pakistan[3] found that repeated applications of ghee, a clarified butter traditionally put on the umbilical cord, was a risk factor for neonatal tetanus. It is usually assumed that the source of infection is the tool used for cutting the cord and traditionally the 'rusted iron knife' is suspected to be the primary source of contamination.[4] Surprisingly, however, there are very few systematic studies of the risk factors of neonatal tetanus and little attention has been devoted to other sources, in particular to contamination by the hands of the birth attendant. Those subjects are of particular importance since there are now many programmes for training traditional birth attendants (TBA) throughout the world.

SUBJECTS AND METHODS

The study was conducted in a rural area under demographic surveillance in Niakhar, Senegal. It is a component of a more comprehensive study on mortality determinants undertaken by the research unit 'Population et Santé' of ORSTOM (Institut Français de Recherche pour le Développement en Coopération).[5] The study area is populated by Sereer peasants. The modern health care infrastructure is poor: two public dispensaries with trained nurses and a Roman Catholic mission with a volunteer nun.

According to the study, Sereer women prefer to deliver at home (89.0%) or in the bush (4.7%) rather than in a rural maternity facility mostly because of a local taboo: women ought not to be heard screaming

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when delivering. However a small proportion went to a modern health facility before delivery (6.3%). Women who deliver at home or in the bush may receive the visit of a birth attendant (40.5%) or go to a local dispensary later. In this case the cord is dressed properly and the newborn child often receives a serum against tetanus (21%). The umbilical cord is traditionally cut with a sliver of wood taken from a local graminae (*Andropogon gayanus*); over the past few decades new modes of cutting the cord have been introduced. Trained birth attendants were taught to use scissors and this new behaviour has been adopted in 47.8% of deliveries. Tetanus toxoid was seldom administered to pregnant mothers prior to 1987: over the study period only 3% of pregnant women received at least one injection of toxoid prior to delivery.

During the study period (1 March to 31 October 1986) all births and deaths that occurred in the study area (30 villages with 24 000 inhabitants) were systematically recorded. There was little chance of omission of either births or deaths since the demographic surveillance was based upon routinely updated maternity histories.[6] Causes of death were assessed through questioning the mothers.[7] More details on the data collection methods can be found elsewhere.[8,9]

For this study, all neonatal deaths (0 to 27 days of life) were reinvestigated in the summer of 1986 to identify the neonatal tetanus deaths. For each case various signs, symptoms and conditions were recorded. Further evidence was received from the clinical diagnosis of a physician or a nurse. Four major criteria were considered for the diagnosis of neonatal tetanus:

(1) symptoms started after the second day of life
(2) trismus (trouble opening mouth after illness began; ceased to suckle)
(3) body rigidity
(4) generalized spasms

A case was defined as having all four major criteria or three major criteria and the clinical diagnosis of a nurse or a physician. The following minor criteria were also considered but they did not enter into the strict case definition: hyper-salivation, constipation, change in skin colour, clenched hands and no fever at onset of symptoms. If fever occurred later in the illness it was considered a sign of increased severity.

STUDY DESIGN

The study had a case-control design. When all the cases were properly identified, they were matched with two types of controls within the same environment:

—all other births that occurred in the same compound (i.e. the dwelling unit of the extended family) during the study period, who survived the neonatal period;
—all other births that occurred during the study period in a neighbouring compound who survived the neonatal period. The neighbouring compound was randomly chosen from the list of all compounds from the same hamlet, with approximately the same size as the compound being studied. As compounds vary in size and type of organization, it was important to control for this factor. No matching other than the size of the compound was done.

Mothers and birth attendants were interviewed and asked to answer a standardized questionnaire. The following epidemiological risk factors were investigated:

—where the delivery occurred (health centres, hut, compound, bush)
—where the mother delivered the baby (bed, material, soil, mattress, plastic)
—who assisted in the delivery (midwife, TBA, relative, other neighbour, none)
—when the birth attendant arrived (before or after delivery)
—who cut the cord (midwife, TBA, relative, other neighbour, none)
—how the cutting was performed (washing hands, ritual, both, none)
—which tool was used to cut the cord (razor blade, knife, stick, glass shard, scissors)
—how the tool was cleaned (alcohol, soap)
—on what surface was the cord cut (water tank, fingers, woodstick)
—whether the delivery was induced (yes/no)
—who performed the cord binding (midwife, TBA, relative, other neighbour, none)
—what material was used to bind the cord (home-made thread, TBA thread, piece of cloth, none)
—what material was used to dress the cord (alcohol, ashes, pottery powder, talc, *karite* butter, mentholatum)
—who dressed the cord (midwife, TBA, relative, other neighbour, none)
—what other procedures were performed (piercing ears, immune-globulin, none)
—whether a TBA came during the delivery for cutting, binding or dressing the cord.

In addition, various socioeconomic factors were examined as possible correlates:

—number of animals belonging to the family (horse, donkey, sheep, goat, pig, cow)
—number of animals staying in the compound (horse, donkey, sheep, goat, pig, cow)
—number of millet granaries
—education level of children and adults
—previous use of tetanus toxoid vaccination or tetanus serum by anyone in compound.

Data were analysed using various modules of SYSTAT, a statistical package for personal computers.

RESULTS

There were 4164 livebirths, 212 neonatal deaths and 66 cases of neonatal tetanus over the study period between April 1983 and October 1986 in the 30 villages (neonatal tetanus death rate = 16/1000). Among the 66 neonatal tetanus deaths, 61 matched the four criteria definition; four matched the three criteria definition (spasms were not reported) plus report from a nurse; the last one was diagnosed by the district physician of Fatick as typical neonatal tetanus. Mothers identified 48 out of 66 (73%) as tetanus (*Kumalass* in Sereer). According to mothers' reports, 39 (59%) had hyper-salivation, 24 (36%) had a change in skin colour and 23 (35%) showed constipation. Some 30 cases (45%) had fever before death (but not at onset of disease), a sign of severity.

The epidemiological investigation on the risk factors was conducted on neonatal tetanus deaths that occurred over exactly three years between April 1983 and March 1986. Questionnaires were completed on 45 cases (out of 48) and 187 controls (78 controls in the same compound and 109 in the neighbouring compound). There was no difference in risk factors according to both types of controls: they have been grouped for the final analysis.

Socioeconomic Differentials

Among socioeconomic factors describing the situation of the compound, there was no difference between cases and controls for any of the categories analysed related to education of parents and children and wealth of the family (Table 1). The mean number of animals, which is not only an indicator of family wealth but also of the risk of higher exposure to tetanus germs, was also not significant.

Use of Tetanus Serum and Tetanus Toxoid

The mean number of women living in the same compound who had received tetanus toxoid earlier on was not significant ($p = 0.0677$) as well as the mean number of newborn children who received tetanus serum ($p = 0.4123$). This later effect is due to a reverse causality: children who died of tetanus were more likely to have received a tetanus serum after the onset of the disease. There was no neonatal tetanus case among children born to vaccinated mothers and no cases among children born to women who delivered in a modern health facility.

Demographic Factors

There was no difference between cases and controls according to sex (sex ratio = 1.14). Mothers of the cases had a lower mean age than mothers of the controls ($p = 0.0262$).

Epidemiological Factors

In contrast, epidemiological risk factors appeared in general as highly significant and showed high odds ratios (OR) (Table 2). These included intervention of a TBA (OR = 5.78; $p = 0.000$); who cut the cord (OR = 5.48; $p = 0.0115$); who dressed the cord (OR = 5.65; $p = 0.0000$); who bound the cord (OR = 4.08; $p = 0.0158$); whether the hands were washed with soap (OR = 5.19; $p = 0.0000$); whether cord was cut with scissors (OR = 5.16; $p = 0.0157$); whether cord was dressed with alcohol (OR = 4.22; $p = 0.0001$); whether the tool used for cutting the cord was cleaned (OR = 2.79; $p = 0.0123$); whether the birth attendant came before delivery (OR = 3.99; $p = 0.0076$); the type of binding (OR = 3.62; $p = 0.0295$); whether the newborn fell on the soil (OR = 2.13; $p = 0.0278$) and whether the mother was under 18 years old (OR = 4.46; $p = 0.0262$). Other variables were not significant with the exception of the season of birth: neonatal tetanus was more frequent during the rainy season (OR = 2.45; $p = 0.0090$). The statistical test used here for analysis was the Mantel-Haenszel Chi-square test. A more refined testing procedure has been tried that takes into account a different number of controls per case.[10] It did not change the results, with the exception of the use of immune-globulin which became significant (higher risk for cases due to reverse causality). Therefore, controls who received immune-globulin during the first three days were kept for final multivariate analysis; an intermediate analysis discarding them showed very similar results.

Multivariate Analysis

A multivariate analysis was conducted for estimating the net effect of each of the major epidemiological factors. The model used was a linear logistic (SYSTAT-LOGIT) model. Results are displayed in Table 3. Washing hands with soap prior to cutting the cord appeared overwhelming when other factors were controlled for: it implied an OR of 5.22 ($p = 0.0001$) which is close to the row effect in the univariate analysis. Three other factors remained highly significant in the multivariate analysis: the age of the mother, the person who dressed the cord and the time at which the birth attendant arrived (before or after delivery). Surprisingly, the effect of the nature of the tool used for cutting the cord disappeared and its sign even became positive, that is a slightly higher (not significant) risk when the cord was cut with scissors, the recommended

TABLE 1 *Mean values of socioeconomic factors (in compound) and of demographic factors (child, mother)*

Factor	Cases (n = 45)	Controls (n = 187)	p	Significance
No. of animals in compound	12.7	12.4	0.8922	NS
No. of millet granaries	15.2	15.5	0.9361	NS
No. of sources of income	1.29	1.56	0.4091	NS
No. of educated children (modern)	1.19	1.78	0.1861	NS
No. of educated children (arabic)	0.70	0.54	0.6850	NS
No. of educated adults in family	0.88	0.90	0.9706	NS
No. of women with previous tetanus toxoid vaccine	0.14	0.45	0.0677	NS
No. of children with previous tetanus toxoid serum	1.21	1.49	0.4123	NS
Age of mother (in years)	27.0	28.8	0.0262	*
Sex ratio of babies (M/F)	1.14	1.10	0.9328	NS

* = $p<0.050$; NS = not significant

way for TBAs. Dressing the cord with alcohol did not show any independent impact: this is not surprising since alcohol is not sporicidal. Extensive work with linear logistic regressions was conducted. None of the other variables was significant when added to the model displayed in Table 3. Season of birth often appeared to be significant, although the associated odds ratio was always small.

Correlations with Significant Variables

Correlations with variables found significant in the multivariate analysis were systematically examined (Table 4). Surprisingly, washing hands was found independent from all other variables, including from TBAs interventions. Time of help and age of mother were also independent from other variables, as expected. Other variables related to TBAs practices (cutting, binding, dressing) were highly correlated.

DISCUSSION

The investigation on the risk factors was conducted retrospectively on the average one year after the birth and sometimes almost three years after the birth. The greatest care was devoted by investigators to gather first-hand information and to match information from the mother with information from the TBA. However retrospective information is never fully free of recall biases. Another bias that could have affected the study came from the matching: controls were chosen among children who survived the neonatal period to ensure

TABLE 2 . *Univariate analysis of epidemiological factors (case/control)*

Factor	Prevalence†	Odds-ratio	95% Confidence interval	p
Intervention of TBA (no/yes)	0.595	5.78	(2.21–16.00)	0.0000*
Who dressed the cord (other/TBA)	0.599	5.65	(2.16–15.66)	0.0000*
Who cut the cord (other/TBA)	0.828	5.48	(1.22–34.27)	0.0115*
Hands washed prior to cutting cord (no/yes)	0.155	5.19	(2.13–12.70)	0.0000*
Cord cut with scissors (no/yes)	0.835	5.16	(1.14–32.31)	0.0157*
Age of mother (<18 years/≥18 yrs)	0.034	4.46	(0.89–22.38)	0.0262*
Cord dressed with alcohol (no/yes)	0.548	4.22	(1.83–10.03)	0.0001*
Who bound the cord (other/TBA)	0.801	4.08	(1.14–17.40)	0.0158*
Time of help (after/before delivery)	0.759	3.99	(1.28–13.87)	0.0076*
Type of binding (other/thread TBA)	0.822	3.62	(1.00–15.50)	0.0295*
Tool cleaned with soap (no/yes)	0.643	2.79	(1.16– 6.98)	0.0123*
Season of birth (rainy/dry season)	0.267	2.45	(1.17– 5.11)	0.0090*
Birth order (1/>1)	0.091	2.28	(0.77– 6.57)	0.0910
Newborn fell on soil (yes/no)	0.487	2.13	(1.03– 4.43)	0.0278*
Where cord was cut (fingers/other)	0.354	1.76	(0.79– 3.99)	0.1355
Use of immune-globulin (no/yes)	0.323	1.61	(0.73– 3.63)	0.2089
Time of delivery (night/day)	0.178	1.34	(0.53– 3.28)	0.4935

†prevalence of high risk condition in the sample (case+control)

* = $p<0.05$

NB For age of mother, one cell has less than five cases. Mantel-Haenszel was inaccurate. Fisher exact test was 0.0478; estimate of relative risk was 2.73 95% CI: (1.30–5.76).

TABLE 3 *Multivariate analysis of risk factors of neonatal tetanus*

Factor	Beta	T	p	Odds ratio
Constant	8.083	3.162	0.0014*	–
Hands washed with soap	−1.653	−3.530	0.0001*	5.22
TBA dressed the cord	−1.549	−2.361	0.0124*	4.71
Age of mother ⩾18 years	−1.950	−1.950	0.0277*	7.03
Help before delivery	−1.423	−2.030	0.0231*	4.15
Scissors used for cutting	+0.705	+0.717	0.2389 (NS)	

Log likelihood = −80.047; Chi-square (5) = 33.875; p<E−10; * = p<0.05

that no neonatal tetanus deaths could possibly be counted among them. This procedure probably disqualified from the controls children with lower birthweight who are more likely to die during the neonatal period. This could partly account for the effect of age of mother: younger mothers who have lower birthweight babies were less likely to be controls than others.

The high odds ratio for neonatal tetanus associated with non-washing of hands suggests that a possible source of spores may be the hands of the birth attendant. This is a new observation, since the tool used for cutting has usually been considered to be primarily responsible for cord contamination. The hands of peasants are more likely to be contaminated with dirt than even a rusty knife. A study conducted in India[11] matched controls with cases from the same TBA; virtually no one was washing hands in this population and the authors did not find any significant risk factors which is indirect confirmation of the Senegalese findings. Hands are easy to clean with soap and water and this may be an important action for preventing neonatal tetanus.

The high odds ratio associated with the dressing of the cord suggests that most contamination occurs at time of dressing. This could explain the major role played by the birth attendants, the results from Pakistan where only repeated applications of Ghee were found significant, and the range of dates at onset of first symptoms (from 2 days to 3 weeks).

The skill and the experience of the mother also appeared significant. The fact that children of very young mothers (less than 18 years) had a 4.7 fold higher risk of contracting tetanus may be due to a lack of appropriate knowledge of basic hygiene. Young women receive very little information prior to their first delivery and they learn maternal skills only with experience. In extreme cases in Africa, women report they did not know how to deliver their first baby.[12] Therefore, developing countries should give a high priority to teaching very young mothers proper healthcare techniques.

The skill of the TBA who dresses the cord and the time at which she intervenes in the delivery process seem to be important determinants. To reduce the risk of neonatal tetanus, TBAs should periodically be reminded of basic delivery techniques.

The absence of socioeconomic differentials in the

TABLE 4 *Pearson correlation coefficients between significant and other variables*

	Hands washed	TBA dressing	Time of help	Mother<18 years
Hands washed	1.000			
TBA dressing	0.092	1.000		
Time of help	0.066	0.210	1.000	
Mother <18 years	−0.006	0.034	−0.156	1.000
TBA intervention	0.097	0.989*	0.229	0.036
TBA cutting	0.183	0.527*	0.272*	0.006
TBA binding	0.164	0.583*	0.282*	−0.053
TBA thread	0.156	0.589*	0.271*	−0.060
Scissors	0.176	0.535*	0.261*	0.001
Tool cleaned	0.080	0.410*	0.153	−0.029
Alcohol used	0.115	0.879*	0.210	0.058
Cut on finger	−0.066	−0.237	−0.172	−0.022
Fell on soil	0.309*	0.264*	0.116	0.081
Season	0.097	0.102	−0.009	0.022
Birth order	−0.004	0.085	−0.135	0.571*
Immune-globulin	0.007	0.532*	0.173	0.030
Time delivery	0.053	−0.100	0.199	−0.092

* = p<0.05

study does not appear to be due to the fact that cases and controls were matched on size of compound. The average size of compounds among cases and controls (19.7) was rather lower than the mean size of compounds in which a birth occurred over the study period (21.8).

The exact mechanism of neonatal tetanus mortality remains largely unknown. Since the tetanus germ is ubiquitous and hygiene is so poor in the rural areas of developing countries, most babies are at high risk of contracting tetanus. The fact that neonatal tetanus deaths occurred more frequently in the rainy season indicates that environmental factors such as temperature and humidity play a role. More important, the dose of infection is likely to be associated with the hygiene and skills of the mother and of the TBA: this may well be the key determinant of severity of infection and of child survival.

Of course, the most important preventive measure for neonatal tetanus remains tetanus toxoid immunization of women of reproductive age and particularly during pregnancy. Shortly after this study was completed, a comprehensive programme of tetanus toxoid immunization for pregnant women was started in the study area. In addition, since the proportion of births attended by trained midwives was still low, mothers were taught basic hygiene and hand cleansing when attending for antenatal examination.

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