Mortality from neonatal tetanus in rural Côte d'Ivoire

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A 30-cluster survey was carried out in order to estimate the incidence of neonatal tetanus in rural Côte d'Ivoire. Births in the 19 months preceding the survey were enumerated by interviewers in house-to-house visits. If a child born in that period had died, the interviewer asked a series of questions to establish a presumptive diagnosis of neonatal tetanus. A total of 41 deaths from neonatal tetanus was found in the study area among 2324 live births that occurred from 1 January 1981 to 31 July 1982. This gives a neonatal tetanus mortality rate of about 2%. Most deliveries and almost all deaths occurred at home, and only about 2% of neonatal tetanus cases were reported through the routine health information system. Birth in a clinic and antiseptic care of the umbilical cord protected infants from neonatal tetanus. Tetanus immunization of all women of child-bearing age is recommended as a preventive measure.

In developing countries, neonatal tetanus is a major cause of infant death. Incidence rates are highest in rural areas, where births usually occur at home and are attended by untrained personnel. In these circumstances, *Clostridium tetani* may infect the umbilical stump and cause neonatal tetanus. The onset of the disease usually occurs between the 3rd and 10th day of life, and most deaths occur between 4 and 14 days of birth. Mortality in untreated cases is probably greater than 90%. In impoverished rural areas, neonatal tetanus may kill from 1% to at least 7% of all newborns (*1–3*). Since anti-tetanus antibodies cross the placenta and protect the newborn (*2*), the disease can be prevented by hygienic perinatal care and/or by immunizing women with tetanus toxoid before they give birth, either before or during pregnancy (*4, 5*). The Côte d'Ivoire expanded programme on immunization (EPI) is working to reduce the occurrence of several vaccine-preventable illnesses of children, including tetanus.

In order to determine the importance of neonatal tetanus as a cause of death, and to obtain baseline data for northern areas of Côte d'Ivoire not included at that time in the national EPI, a household survey was carried out in the adjoining districts of Boundiali and Tengrela in August and September 1982. These districts were chosen because they lie in an area where animal husbandry is an important economic activity (Fig. 1). The total population of the two districts is
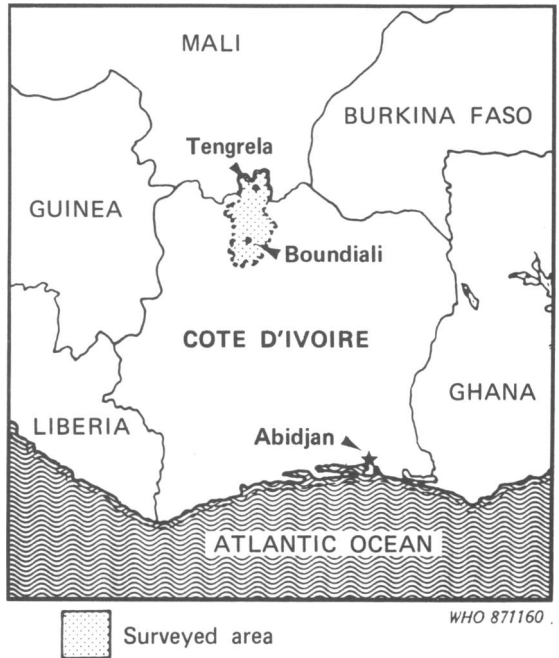

Fig. 1. Location of survey of neonatal tetanus mortality, northern Côte d'Ivoire, 1981–82.

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148 000, and there are maternity clinics in the six largest towns. Because human or equine tetanus antisera are routinely prescribed for newborns in these clinics, these towns (total population, 33 000) were excluded from the survey. The 115 000 inhabitants of the remaining villages formed the study population. Most houses in the area are constructed of mud-bricks and thatched roofs; domestic animals (cattle, pigs, sheep, and goats) roam freely around the houses. Water is drawn from community wells and there is no electricity. Tetanus toxoid immunization is not available in these villages. Local health authorities report that this region has never had a mass immunization campaign against tetanus, although measles and BCG vaccines are given by mobile teams that visit each village every 1–2 years.

MATERIALS AND METHODS

Sample size

Data from other developing countries suggest that in rural areas where modern maternity services are not available the neonatal tetanus mortality rate is $\geqslant 1\%$. Based on a 1% incidence rate of neonatal tetanus, we estimated the required sample size for the study using a Poisson distribution. If the true incidence rate of neonatal tetanus in a cohort of 2000 births is 1% (20 cases), there is a 90% probability of detecting an incidence rate of at least 0.75% (15 cases). This detection probability was judged to be satisfactory, although the precision of a study that identified 20 cases would only be about 50%.

Survey methods

In order to simplify the field work, a cluster survey was carried out based on the WHO methodology for evaluating immunization coverage.[a] The required 2000 births were divided by 30, the number of clusters, to give a minimum number of 67 births per cluster. A recall period of 20 months was used because it gave a starting date of 1 January 1981, a date likely to be remembered by study respondents. All live births that occurred from 1 January 1981 to 31 July 1982 (19 months) were included. Births that occurred in the month before the survey were excluded since not all these infants had completed the 28-day neonatal period.

Assuming a birth rate of 45 per 1000 population per year, we estimated that on average, a total population of about 950 would be needed in each cluster to find 67 births; however, in order to set a margin of safety,

a cluster size of 1500 was used. Using a list of the villages and their inhabitants, we constructed a table of cumulative total populations, calculated the sampling interval, and selected 30 villages as clusters. If the population of the village was less than 1400, the nearest neighbouring village was also included in the cluster. The survey was carried out in each cluster by walking from house to house and asking each woman whether since 1 January 1981 she had been pregnant and if so about the outcome of any deliveries, until a total of 72 live births had been identified. Births and deaths were listed, and mothers of children who had died during the neonatal period were questioned *inter alia* about the circumstances of the delivery, care of the umbilical cord, whether their child had been circumcised, and the cause of death. Mothers of children who died in the post-neonatal period were also questioned about the cause of death.

To determine risk factors for neonatal tetanus, we randomly selected 12 controls in each cluster (about one out of each six live births). Controls were chosen by selecting digits at random from the serial numbers on bank notes and marking the corresponding lines of the census form before beginning the day's interviewing. The mothers of controls were asked the same questions about the circumstances of delivery and perinatal care as the mothers of children who died during the neonatal period.

Data were recorded on the three forms described below:

—a census form to record each live birth identified, the month of the birth, and whether the child was alive or dead at the time of the survey;
—a questionnaire to record information on all children (study and control groups) who died during the neonatal period; and
—a questionnaire to obtain data on children who died after the neonatal period.

The death of a child who met all the following criteria was attributed to neonatal tetanus:

—normal at birth and breast-fed normally for at least the first 2 days of life;
—stopped breast-feeding at the beginning of the illness; and
—died before 28 days of age with convulsions or spasms.

We prepared a list of terms for symptoms and signs of illness in the two local languages, Dyula and Senufo. Interviewers and translators were trained in the use of the questionnaires before beginning the survey, and after the first day of field work an additional training session was held to review procedures and address any questions or problems. Six survey teams were used, each consisting of a team leader, two interviewers, a driver, and, if necessary,

[a] WHO EXPANDED PROGRAMME ON IMMUNIZATION. *Training for mid-level managers: evaluate vaccination coverage.* Unpublished document, 1979.

a translator. To ensure that each team could communicate in both of the local languages, nine local high school students were recruited and trained to act as interpreters. Three of the team leaders were physicians. The survey teams worked in Boundiali and Tengrela districts from 25 August to 13 September 1982. Field work was completed in 12 days, and the additional time was taken up with training and transportation. Two villages were eliminated because of impassable roads and the closest accessible villages substituted in their place.

A calendar of important local events was compiled and given to each interviewer; for example, January is the month of the rice harvest, and October is the month when agricultural credits are given to farmers by the Rural Development Bank. During the interview, parents were asked to produce the birth certificates of their children, but if a certificate was not available, the month of birth was determined using the events calendar.

Since the survey was conducted during the rainy season when most agricultural work is performed, it was important that interviewers arrived in the villages early in the day to speak with the traditional chief and political officer before the villagers left for the fields. Depending on the distance they had to travel and road conditions, interview teams left for their assigned villages between 03h 00 and 05h 00.

For the survey, the interviewers divided the villages into quadrants and moved from door to door accompanied by an interpreter and by a representative of the village chief. The interviews were usually complete by 10h 00 or 11h 00, and afternoon meetings of survey staff were held regularly to discuss questions or problems about the study methodology, road conditions, etc. On average, each interviewer found 18 live births per day; thus, two teams of two interviewers each could complete one cluster in a day. In addition to the field survey, hospital registers were reviewed to identify hospitalized cases of neonatal tetanus.

Data analysis

The data were analysed at the Institut National de Santé Publique, Abidjan. Information from the questionnaires on all neonatal deaths and controls was first coded and entered on standard 80-column computer cards, which were then sorted repeatedly on a high-speed sorter[b] to provide tabulations and cross tabulations. Analysis of post-neonatal deaths and life-table analysis were carried out by hand or on a programmable calculator.

To determine the causes of post-neonatal deaths, three of the authors (D. C. S., G. I.-B., and G. S.)
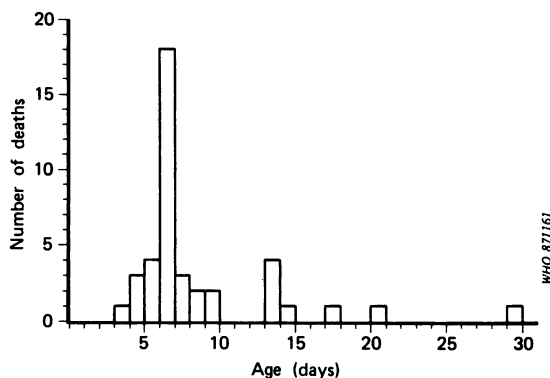
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[b] Honeywell.

Fig. 2. Number of deaths from neonatal tetanus by age, northern Côte d'Ivoire, 1981–82.

independently examined the questionnaire data on symptoms and signs of the fatal illness. If at least two of the three authors agreed on the cause of death, it was accepted; however, if they did not agree, the cause of death was classified as "unknown."

A χ^2-test with Yates' correction for continuity (6) was used to analyse risk factors in the case–control study, while confidence limits on the relative risks were obtained using the programs written by Rothman & Boice for use with programmable calculators (7). To calculate the infant mortality rate, we used the actuarial method for analysis of survival curves (8).

RESULTS

A total of 2324 live births were found, and in about 10% of cases dates of birth were obtained from birth certificates. Altogether, 80 neonatal deaths were identified, which is equivalent to a neonatal mortality rate of 34 per 1000 live births. Of these deaths, 41 met the case definition for neonatal tetanus, giving a neonatal tetanus mortality rate of 18 per 1000 (95% confidence limits, 13–24 per 1000). One additional child was hospitalized for neonatal tetanus and survived.

The age at death from neonatal tetanus ranged from 4 to 30 days, with a mean of 9 days (Fig. 2); 90% of cases died between the 4th and 14th day of life.

We compared the gender, ethnic group, circumcision status, ear-piercing status, place of birth (at home or in a health facility), and type of umbilical cord care (modern or traditional) of the 42 cases of neonatal tetanus with those of the 337 controls. The relative risks associated with these various factors are shown in Table 1. Neither sex nor ethnicity was associated with an increased risk of neonatal tetanus (of the 42 cases, 22 were male and 20 female).

Table 1. Relative risks and significance of risk factors for neonatal tetanus, rural Côte d'Ivoire, 1981–82.

Risk factor	Point estimate of relative risk	Corrected χ^2-test	P value
Male sex	0.90 (0.48–1.72)[a]	0.82	0.34
Ethnic group (Senufo versus others)	0.65 (0.30–1.41)	0.02	0.89
Circumcision	0.12 (0.03–0.45)	8.58	0.003
Ear piercing	0.33 (0.13–0.86)	4.28	0.039
Birth at home	>5.8[b]	4.51	0.017[c]
Traditional umbilical cord care	7.5 (1.35–41.7)	4.26	0.020[c]

[a] Figures in parentheses are 95% confidence intervals.

[b] Cannot be calculated because no tetanus deaths occurred among children born in clinics.

[c] Determined using a one-tailed test.

Interestingly, circumcision (for boys) or ear piercing (for girls) was significantly associated with the *absence* of neonatal tetanus, even when the timing of these procedures was within the first week of life, possibly because infants who appeared ill were not circumcised or did not have their ears pierced. Most control infants did not undergo circumcision or have their ears pierced during the first week of life.

Place of birth significantly influenced the occurrence of neonatal tetanus; all neonatal tetanus cases were delivered at home, compared with 88% among the controls (Table 2). This difference is significant (relative risk >5.8). All home deliveries were performed by family members or by traditional birth attendants who had not received formal training.

Traditional umbilical cord care was significantly associated with neonatal tetanus. The mothers of one (2%) of the tetanus cases and of 53 (16%) of the controls reported that the umbilical stump was cared for in a hygienic fashion (Table 3), a difference that is significant, with a relative risk of 7.5. Traditional

Table 2. Place of birth of neonatal tetanus cases and controls, rural Côte d'Ivoire, 1981–82

Place of birth	No. of tetanus cases	No. of controls	Total
Home[a]	42	290	332
Clinic	0	40	40
Total	42	330	372

[a] $\chi^2 = 4.51$, $P < 0.025$, one-tailed test; relative risk, >5.8.

Table 3. Comparison of cases of neonatal tetanus and controls according to type of umbilical cord care, rural Côte d'Ivoire, 1981–82

Cord care	No. of tetanus cases	No. of controls	Total
Traditional[a]	40	283	323
Modern	1	53	54
Total	41	336	377

[a] $\chi^2 = 4.26$, $P < 0.025$, one-tailed test; relative risk, 7.5 (95% confidence interval: 1.35–41.7).

umbilical cord care in Côte d'Ivoire includes use of dressings consisting of oil from the nuts of a local tree, plant leaves, and/or cotton wool.

Most of the neonatal deaths occurred at home; of the 79 deaths where the place of death was known, 73 (92%) were at home, five at a clinic, and one in a hospital.

The records of the two hospitals in the region were examined. At the Boundiali Hospital, records of only two children with neonatal tetanus were identified among infants born between 1 January 1981 and 31 July 1982; both children survived. At the Tengrela Hospital, records of seven children with neonatal tetanus were found, two of whom died. One of the surviving children had been identified during the door-to-door survey. None of the other children with neonatal tetanus in either hospital was from villages included in this survey. If it is assumed that all hospitalized cases were reported to the Ministry of Health, only about 2% of neonatal tetanus cases identified in this survey were drawn to the attention of the authorities.

Table 4 shows the number of births, neonatal deaths, and causes of death according to recall interval before the survey visit. The results of the survey indicate that the number of births reported per month increased substantially for the period closest to the survey interview: 87 per month during the first half of 1981, 122 per month during the second half of 1981, and 150 per month during the first 7 months of 1982. This is not likely to be due to differences in birth rates. In addition to the difference in the numbers of children found, the mortality rate for the second half of 1982 was higher than that for 1981. This may be related to the season when the survey was carried out and to the length of the recall period.

Investigation of the causes of post-neonatal infant deaths (Table 5) indicated that of 62 such deaths, 50 were ascribable to specific causes, and three of the investigators agreed that measles and/or diarrhoea caused the death of 25 of these infants. Other causes

Table 4. Comparison of mortality rates from neonatal tetanus and overall mortality rates, according to length of recall period, rural Côte d'Ivoire, 1981–82

Recall period (months between birth and survey)	No. of live births surveyed[a]	No. of neonatal deaths			Neonatal mortality rates (per 1000 live births)	
		Tetanus	Other causes	Total	Tetanus	Total
14–19	524	3	11	14	6	27
8–13	731	10	10	20	14	27
1–7	1052	28	18	46	27	44
Total	2324	41	39	80	18	34

[a] Information on recall periods was not available in 17 cases.

of death included pneumonia, malaria, tetanus, pertussis, and meningitis. Most (90%) of the 62 post-neonatal deaths occurred at home, and only two children died in a clinic and four in hospital.

Using an actuarial life table method, we calculated that the probability of survival at the end of the first year of life was 92.8% (928 per 1000). This corresponds to an infant mortality rate of 72 deaths per 1000 live births (Fig. 3) (95% confidence limits, 57 to 87 per 1000).

DISCUSSION

Stanfield & Galazka reviewed the occurrence and control of neonatal tetanus and noted that routine reporting systems substantially underestimate the extent of the problem (3). Data from two surveys in

Table 5. Causes of post-neonatal mortality, rural Côte d'Ivoire, 1981–82

Cause of death	No. of deaths
Measles	15 (24)[a]
Diarrhoea	15 (24)
Pneumonia	7 (11)
Malaria	6 (10)
Tetanus	3 (5)
Pertussis	2 (3)
Meningitis	2 (3)
Unknown	12 (19)
Total	62 (99)[b]

[a] Figures in parentheses are percentages.
[b] Does not sum to 100% because of rounding.

other African countries indicate neonatal tetanus mortality rates similar to those in Côte d'Ivoire: 12 and 7 per 1000 live births in Malawi and Cameroon, respectively (3). Based on this evidence and the present data, it is estimated that about 150 000 deaths from neonatal tetanus occur annually in the whole of Africa.

Under-reporting of neonatal tetanus

In the study, only one of the 42 infants with neonatal tetanus was hospitalized. If it is assumed that this case was correctly reported through the different
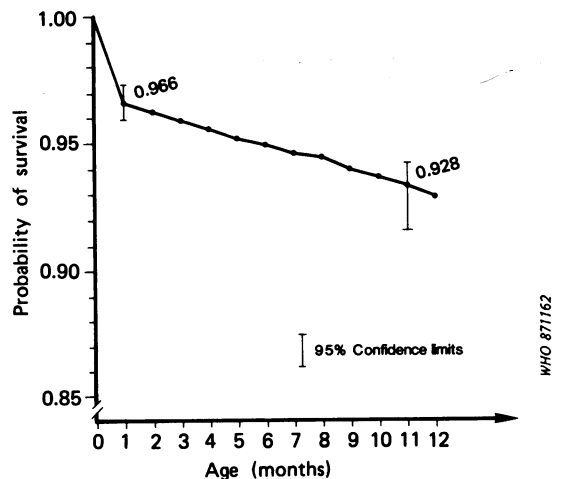

Fig. 3. Probability of survival during first year of life by age, northern Côte d'Ivoire, 1981–82.

levels of the health statistics system, only 2% of neo-natal tetanus cases are covered. This is in good agree-ment with estimates of 2% and 5% reporting made by WHO for the Eastern Mediterranean and South-East Asia Regions, respectively (9).

Under-ascertainment of neonatal mortality

Our calculated infant mortality rate (72 per 1000) is substantially lower than other estimates for Côte d'Ivoire (G. Imboua-Bogui, personal communi-cation, 1982) and probably underestimates the true rate by ≥50%. A major reason for poor ascertain-ment of infant deaths in the survey may have been its timing. During the rainy season, villagers leave early to go to work in the fields, and despite our requests to village chiefs that villagers remain at home until they had been interviewed, many women did not do so after 09h 00. Also, women with very young infants (less than 8 months of age) may be more likely to remain at home than women with older infants or those whose youngest child had died. This hypothesis would partly explain the differences, depending on the recall period, in the numbers of children enumer-ated and in the mortality rates shown in Table 4.

Of the 44 neonatal deaths that occurred in the 7 months immediately preceding the survey visit, 27 (61%) were due to neonatal tetanus versus only 6 out of 27 (22%) for the 14–19 months before the survey period. This difference may have been due to the failure of mothers to recall the specific signs of tetanus for deaths that occurred progressively further in the past. Of 71 neonatal deaths in the final two-thirds of the study period, 41 (58%) were due to neo-natal tetanus.

Based on these observations, we suggest that sur-veys for neonatal tetanus use as short a recall period as possible, certainly not longer than 1 year. The disadvantage of using a shorter period than this is that a larger number of households would then have to be visited in order to find the required number of live births, while an advantage of using a 1-year period is that the overall infant mortality rate can also be estimated.

Control strategies

The following strategies have previously been recommended for the control and elimination of neo-natal tetanus in Africa (10):

— the training of traditional birth attendants to improve hygiene at the time of birth;
— immunization of pregnant women with tetanus tox-oid at antenatal clinics; and
— immunization of all women of childbearing age with tetanus toxoid.

The strategies used in any particular region or country must, however, be adapted to local con-ditions and resources. For example, in Burkina Faso, mass immunization campaigns in several areas have administered the six EPI-recommended vaccines to children and tetanus toxoid to all adults (11). In the Fada N'Gourma area of the country, the estimated coverage achieved was 62% for the first dose and 50% for the second dose of tetanus toxoid. After the campaign, hospital admissions for tetanus decreased from an average of 104 cases per year to 36 cases per year (11).

A major problem in mass immunization campaigns using mobile teams is the attainment of high coverage rates, especially in rural areas. The presence of trained birth attendants and other primary health care workers in a village should improve this situation as their efforts in health education are heeded by vil-lagers and as their input into the design of immun-ization campaigns increases.

Berggren reported excellent results for an immun-ization programme in rural Haiti that used various novel strategies to encourage all women of child-bearing age to be immunized against tetanus. This suggests that immunization was more effective than training of traditional birth attendants in reducing the incidence of neonatal tetanus (12). However, it should be noted that in this case tetanus toxoid was given as one part of a comprehensive health care pro-gramme (13).

A more rigorous operational study of how best to reduce neonatal mortality from tetanus was carried out by Rahman in Bangladesh in a comparative study of the mortality rates in infants born to three groups of women: a control group; a group given tetanus toxoid alone; and a group that did not receive vaccine, but were delivered by trained traditional birth attendants (TBAs) (14). The study showed that while tetanus toxoid was slightly more effective than training TBAs in preventing neonatal tetanus, the total neonatal mor-tality rate was lower among infants delivered by TBAs, because there were fewer deaths from birth injuries and respiratory diseases.

In the region of Côte d'Ivoire where the study was carried out, a high proportion of women gave birth at home and there was no training programme for TBAs. It is unlikely that making tetanus toxoid available at antenatal clinics will markedly increase the number of women who are immunized unless new approaches to the provision of antenatal care are taken. In this respect, the most promising attempt to control neonatal tetanus in this rural environment may be tetanus toxoid mass immunization campaigns aimed at either all pregnant women or the entire population, combined with a health education pro-gramme for TBAs. Preferably such campaigns would

be conducted as part of the initiation of EPI in the area. As immunized children grow up and the provision of primary health care services improves, the need for mass campaigns should decrease.

ACKNOWLEDGEMENTS

RÉSUMÉ

MORTALITÉ DUE AU TÉTANOS NÉONATAL DANS LES ZONES RURALES DE LA CÔTE D'IVOIRE

Dans de nombreux pays en développement, le tétanos néonatal contribue pour une large part à la forte mortalité infantile. Pour évaluer la gravité de la maladie dans les zones rurales de la Côte d'Ivoire, une enquête portant sur 30 grappes a été effectuée, en août–septembre 1982, dans le nord du pays. On a choisi au hasard des villages situés en secteur rural dans les districts de Boundiali et de Tengrela (population: 115 000 habitants) qui n'avaient jamais fait l'objet d'une campagne de vaccination. Les enquêteurs se sont rendus de logement en logement pour effectuer une enquête rétrospective destinée à déterminer le nombre de naissances et de décès survenus au cours des 19 mois précédents, de janvier 1981 à juillet 1982. Si un enfant né au cours de cette période était décédé, l'enquêteur posait une série de questions pour établir un diagnostic présomptif. On a décidé d'incriminer le tétanos néonatal chaque fois qu'il s'agissait d'un nourrisson normal à la naissance, ayant pleuré et tété normalement pendant au moins les deux premiers jours de son existence, puis ayant présenté des contractures musculaires. Une naissance sur six environ a été prise au hasard pour la constitution d'un groupe témoin permettant d'évaluer les facteurs de risque du tétanos néonatal.

Au total, 41 décès dus au tétanos néonatal et 39 autres décès néonatals ont été constatés chez les 2324 enfants nés vivants entre le 1er janvier 1981 et le 31 juillet 1982, ce qui équivaut à un taux de mortalité par tétanos néonatal d'environ 2%. La plupart des accouchements et presque tous les décès ont eu lieu à domicile et, dans le cas des accouchements à domicile, c'est presque toujours un membre de la famille sans formation ou une accoucheuse traditionnelle qui avait assisté la parturiente. Les soins traditionnels pratiqués sur le cordon ombilical consistent à appliquer du beurre de karité, graisse végétale produite sur place, avec des feuilles ou du coton hydrophile. En revanche, on a constaté que le traitement antiseptique du cordon ombilical et la naissance dans un dispensaire conféraient une protection contre la maladie. Le risque relatif présenté par un traitement inadéquat du cordon ombilical et la naissance à domicile a été évalué respectivement à 7,5 ($P<0,025$) et $>5,8$ ($P<0,025$).

Au total, on a décelé 62 décès post-néonatals. Quinze (24%) ont été attribués à la rougeole et 15 autres (24%) à la diarrhée. En utilisant une méthode actuarielle basée sur des tables de survie, on a estimé la mortalité infantile à 72 décès pour 1000 naissances vivantes (limite de confiance à 95%: 57 à 87 pour 1000). Ce chiffre est probablement sous-estimé car l'étude a été faite pendant la saison des pluies où hommes et femmes quittent leur domicile pour travailler dans les champs, de sorte qu'ils n'étaient pas toujours présents pour les entrevues. En outre, on avait moins de chances de trouver chez elles les femmes dont le dernier enfant était récemment décédé que celles dont les jeunes enfants étaient vivants.

La vaccination de toutes les femmes en âge de procréer est probablement le moyen le plus efficace d'éliminer le tétanos néonatal dans les zones rurales de la Côte d'Ivoire, et il faudrait en tenir compte dans le programme PEV.

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